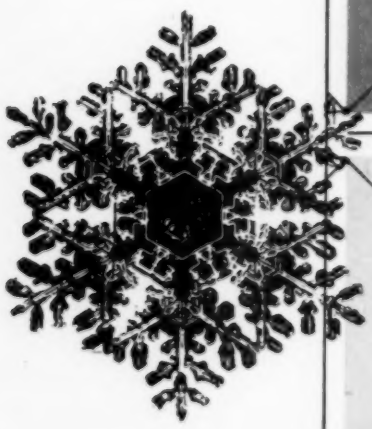
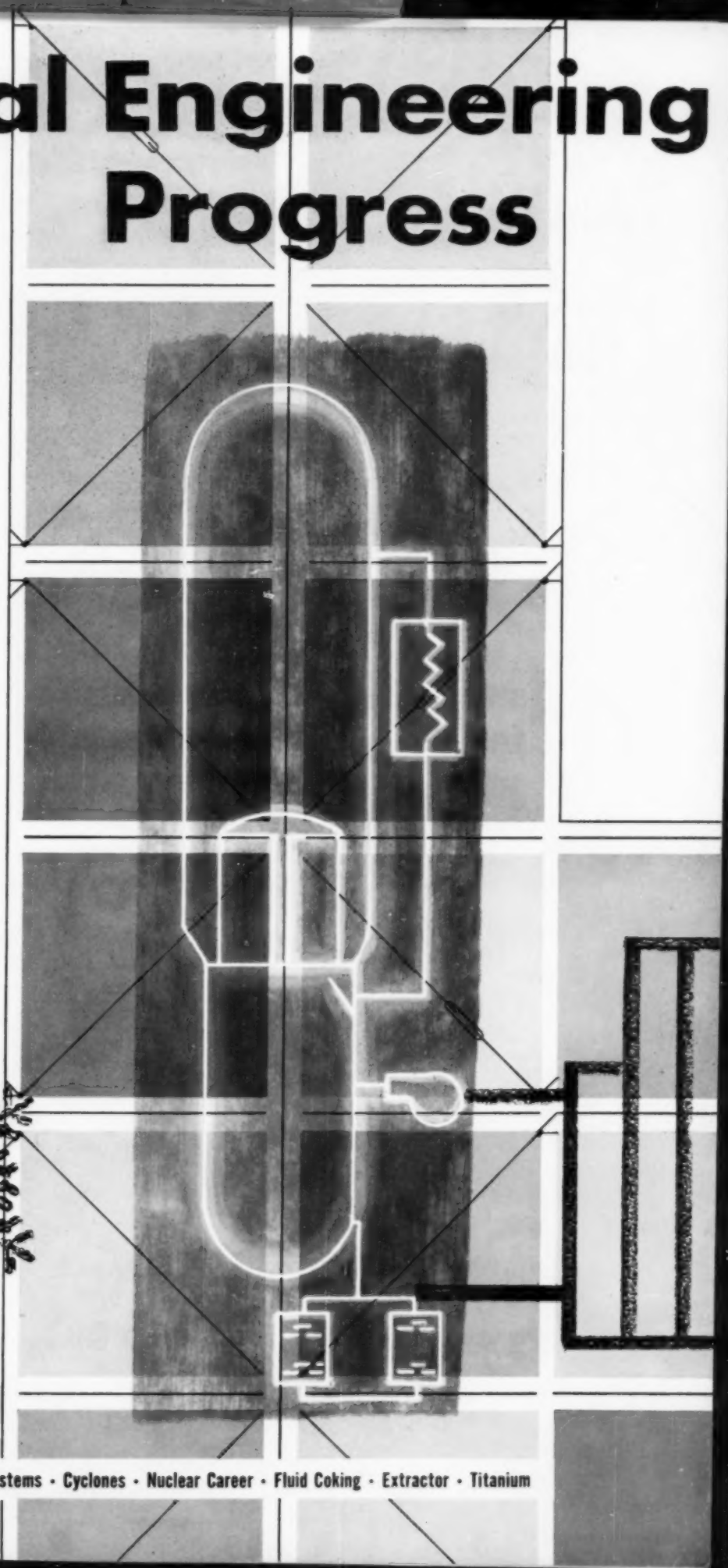
Chemical Engineering Progress

APRIL 1955

ORGANIZATIONAL PLANS
How They Can Be Made to Work

LOW TEMPERATURE PROCESSING
ALTERNATE TECHNIQUES AFFECT COST





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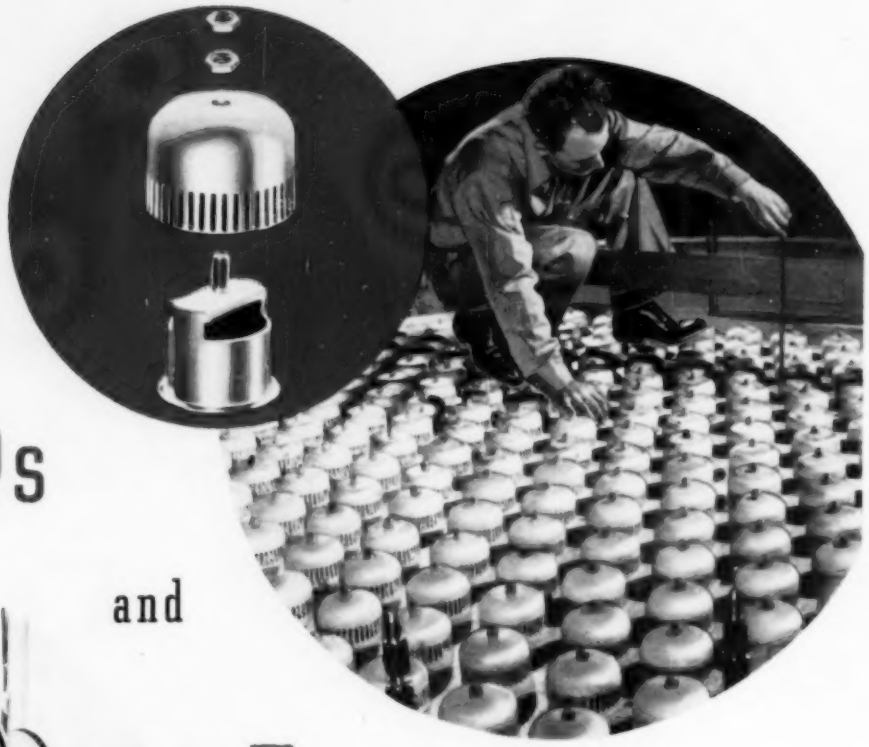
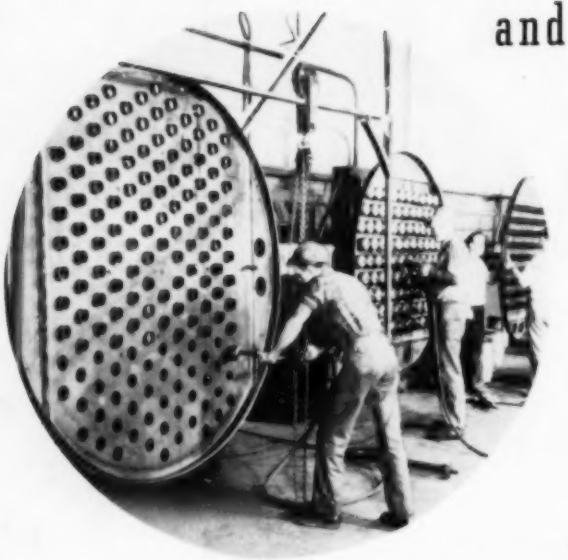


Bubble Caps and Trays



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Chemical Engineering Progress

APRIL, 1955 • Volume 51, No. 4

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this month's cover

Low temperature processing is the theme, and the oxygen-nitrogen separation tower (housed in a "cold box") is the principal symbol. Crystal of snow (picture taken at M.I.T., we understand) depicts the frost always present at any exposed outlet. All of this has to do with the article by Van Dyke and Dougherty (Air Products, Inc.) beginning on page 157 of this issue. Subject: You guessed correctly; it's "low temperature processing."

—cover by Milton Wynne Associates.

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For a brief description of each article . . . see "What's In This Issue"—page 31

The VIBROX Barrel and Drum Packer with the exclusive mechanical rocking-vibrating motion packs more material in the drum or barrel or permits the use of smaller, lower-cost containers; cuts packing time; and reduces packing labor as much as one-third. Yes, in packing most dry powdered, flake, or granular materials, the VIBROX Packer makes a big difference in the over-all packing costs—big enough, many users say, to pay for the VIBROX in a few months.

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Fig. 2309—Flush Bottom Tank Valve for 150 Pounds W. P. Disc Opens Into Tank.

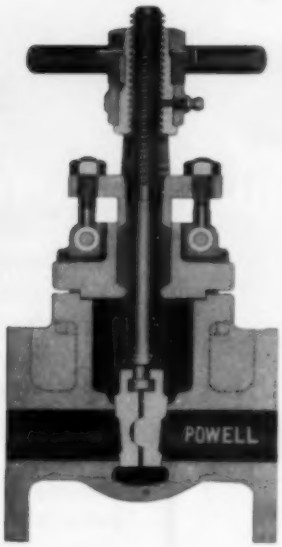

FIG. 2495 (Sectional)—Stainless Steel O. S. & Y. Gate Valve For 150 Pounds W. P. Double Wedge Disc Is Accurately Guided Into Seat.

FIG. 2342—Flanged End Bolted Cap Swing Check Valve. For 150 Pounds W.P.

FIG. 3059-G—300-Pound Steel Lubricated Plug Valve. Gear Operated.

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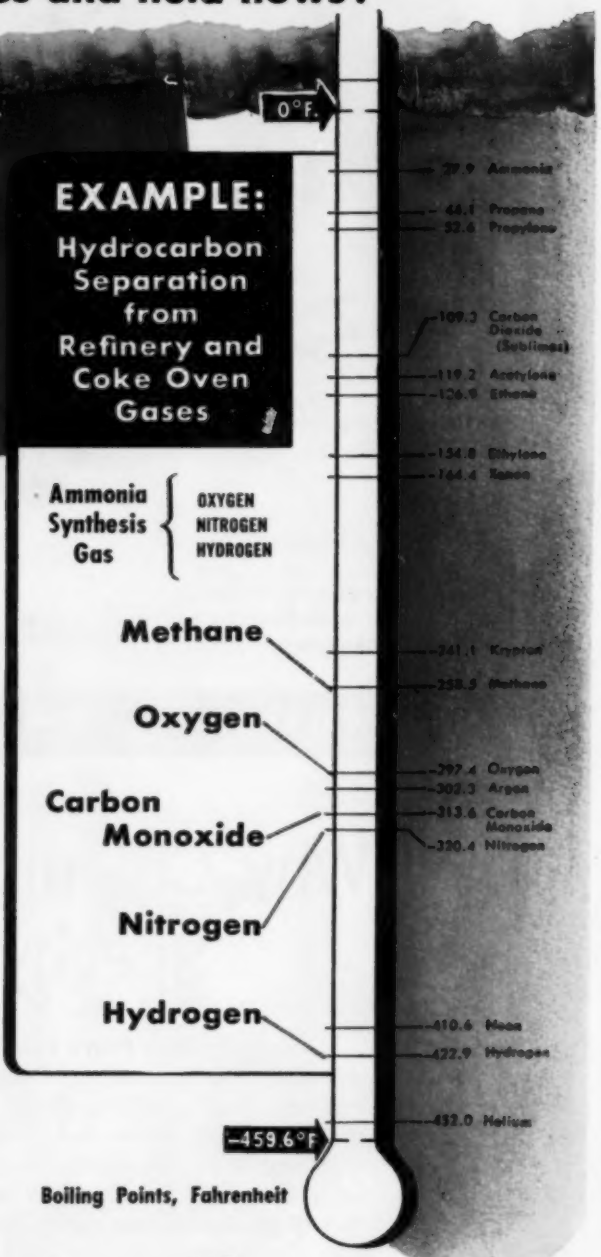

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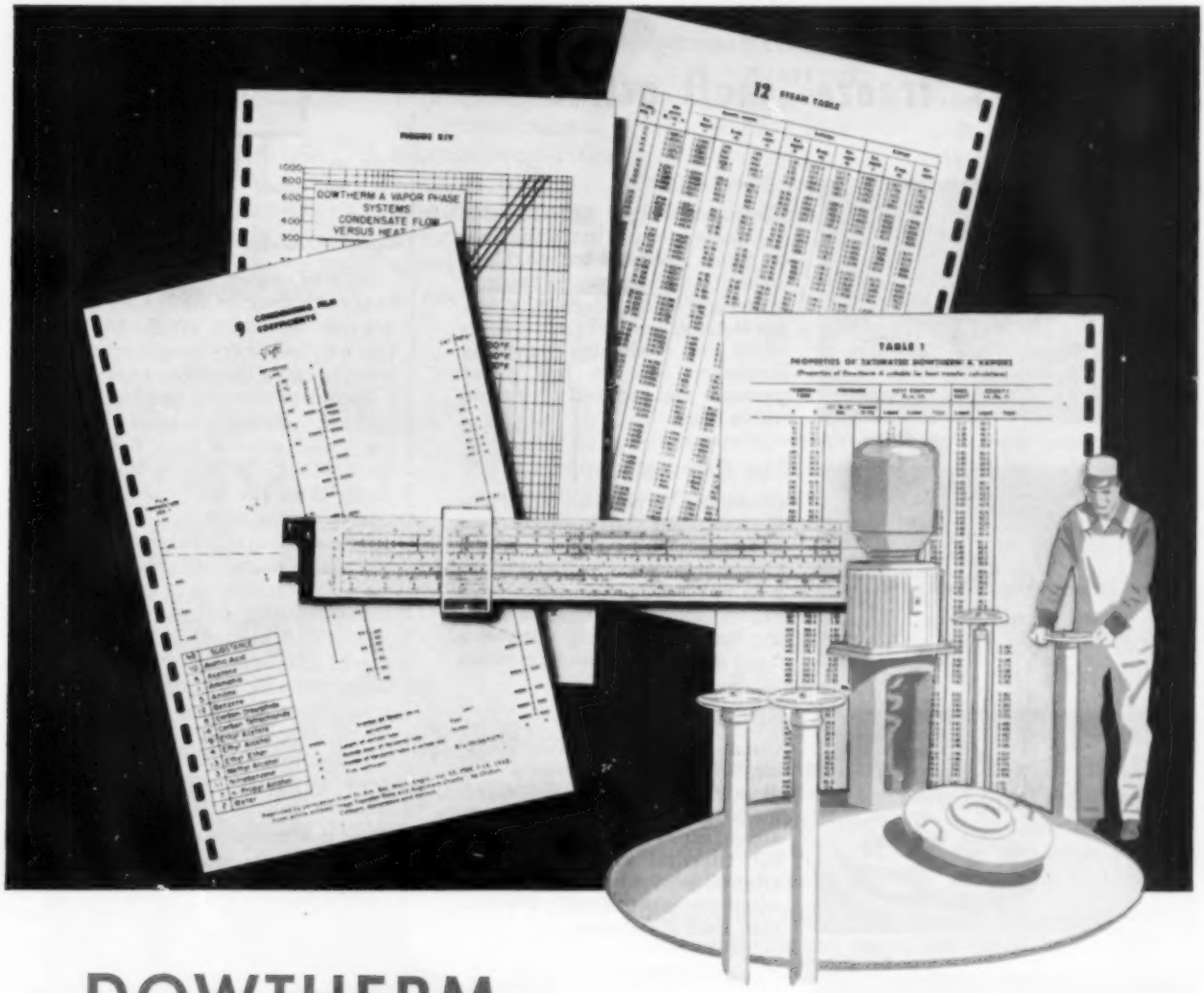

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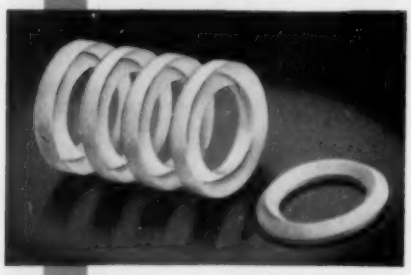

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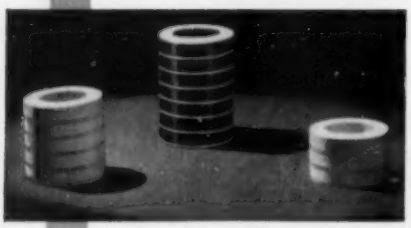

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LETTERS TO THE EDITOR

Operations Research Defined

In your section, "Highlights of the technical articles" in the January issue, you describe Mr. Rio's article on "Quality Control", and end, "sometimes this technique is called 'operations research' ".

Operations research (also called operations analysis or operations evaluation) has a much broader scope than statistical quality control. Primarily, operations research is the selection of alternative processes and procedures by evaluation of all significant factors; preferably by means of statistical methods. Since these evaluations are usually performed to serve as a basis for management decision, the question of probability must have been essentially eliminated. It is true, of course, that many highly profitable "operations analyses" have resulted from an effective statistical quality control program.

Polonius is depicted as a garrulous old wind-bag, but he hit the nail on the head when he declaimed (Hamlet II, i):

"And thus do we of wisdom and of reach,
With windlasses and with assays of bias,
By indirections find directions out:"

FRANK P. VANCE

Idaho Falls, Idaho

Greetings from the Land of the Midnight Sun!

. . . The year here is very interesting and professionally well worth while. The school [Institutt for Kjemiteknikk Norges Tekniske Høgskole] is the only engineering school of university grade in Norway, is entirely state-supported and has about 1200 students. Staff and equipment are such as we would find in a U. S. school of this size. Chemical engineering received much stimulus when Olaf Hougen was here as a Fulbright professor in 1950-51. In a few years the curriculum and equipment for chemical engineering should be much like those in the U. S. The quality of the students is high and the graduates make good records.

My work so far has mostly been to get a course in chemical plant design and

(*Continued on page* 14)

THESE FLUIDS ARE DIFFICULT TO PUMP

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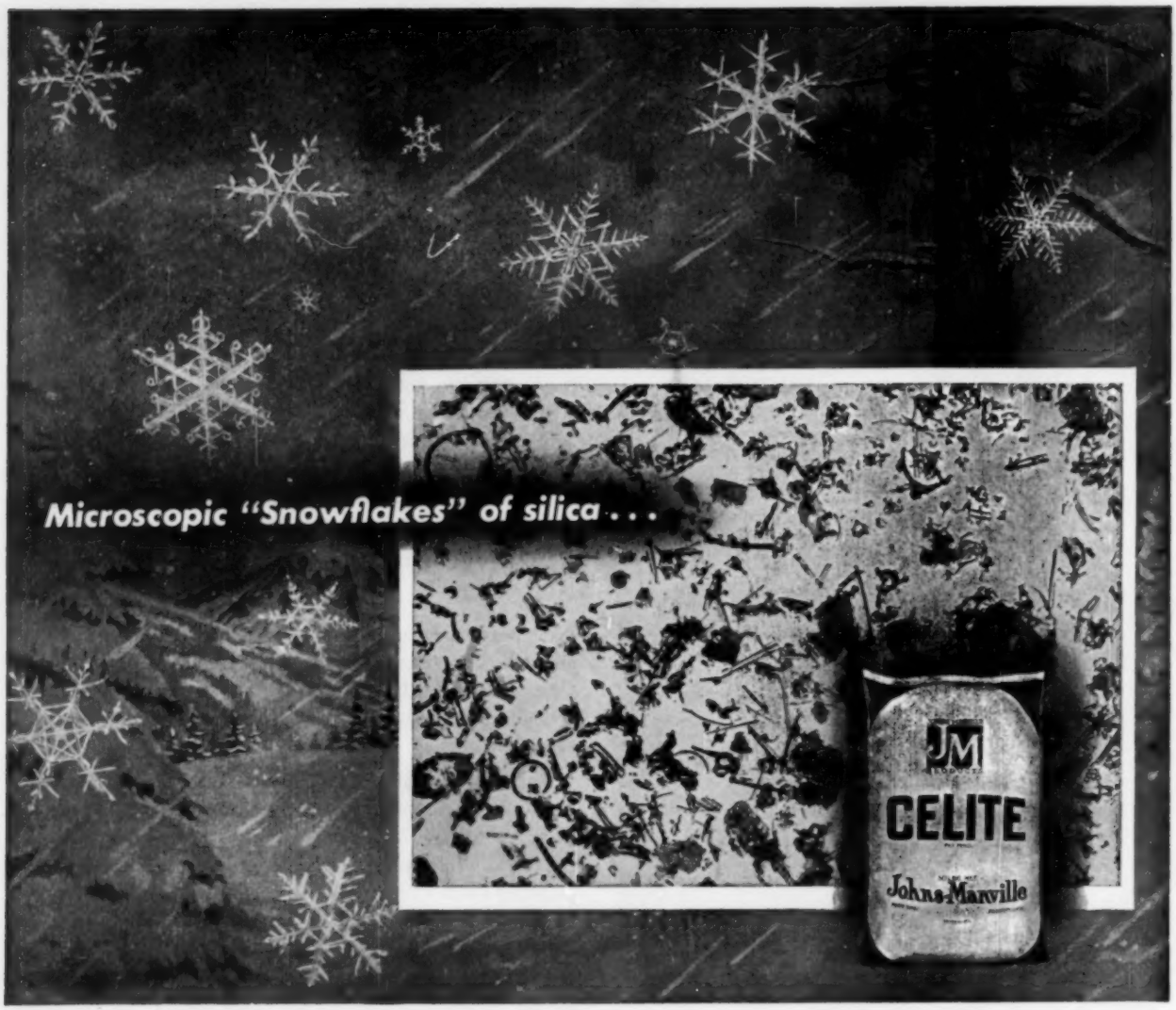
Justification for this specialized premium construction is evident in the many, and varied, applications in which Lapp PULSAFEEDER alone is able to perform satisfactorily. In fact, the economies of continuous processing, automatic proportioning, feeding and filling in many operations are possible only because of the unusual characteristics and peculiar advantages of Lapp PULSAFEEDER.

In general, use of the Lapp PULSAFEEDER is indicated for continuous (or intermittent) pumping, at accurately controlled volume, of fluids which cannot be satisfactorily exposed to conventional pistons, cylinders and stuffing box packing—because of the corrosive action of chemicals being handled and/or need for protection of product against contamination.

Lapp Bulletin 440 shows typical applications and flow charts. It describes and lists specifications of models over a wide range of capacities and special constructions. Also included is an Inquiry Data Sheet, from which we can make specific engineering recommendations for your processing requirement. For your copy write Lapp Insulator Co., Inc., Process Equipment Div., 405 Wilson St., Le Roy, N.Y.



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Moreover, Celite particles in mass have great bulk per unit weight, so they are invaluable for extending, dispersing or fluffing up dry powders. They have high absorptive capacity, too, so they keep powders free-flowing, they serve as a medium for shipping or storing liquids in a dry form.

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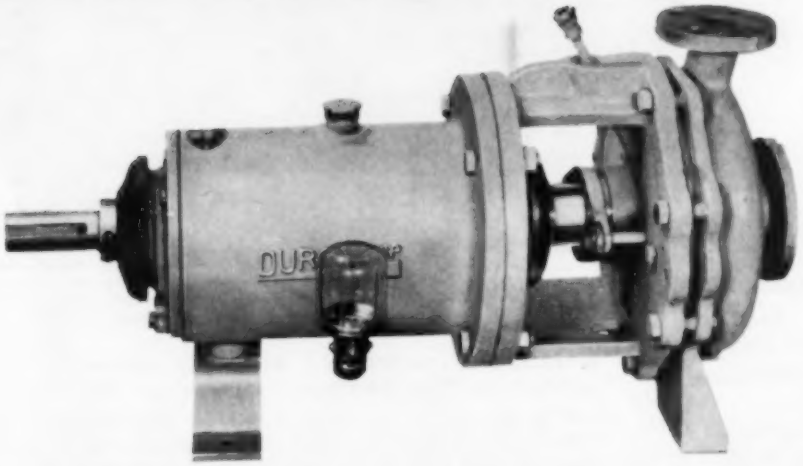

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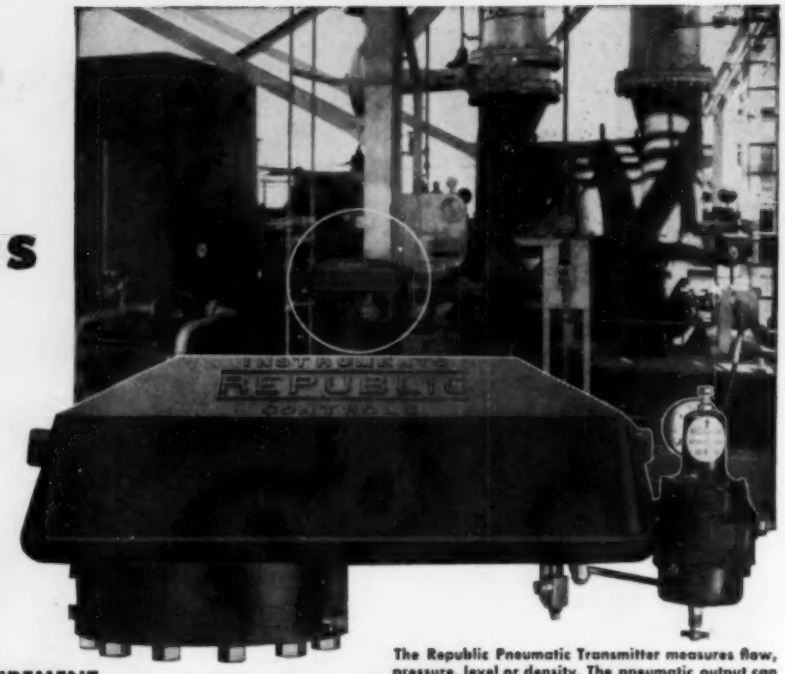

The Republic Pneumatic Transmitter measures flow, pressure, level or density. The pneumatic output can be used to operate reading instruments and as the measuring impulse to an automatic controller.

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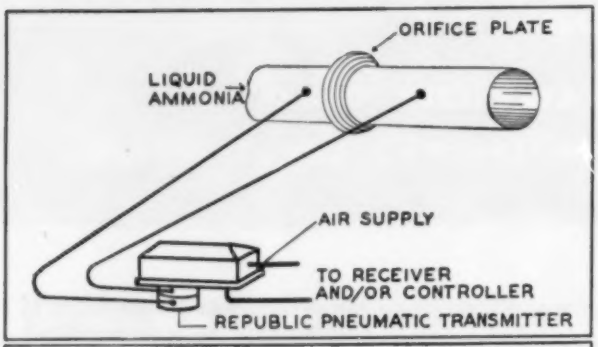

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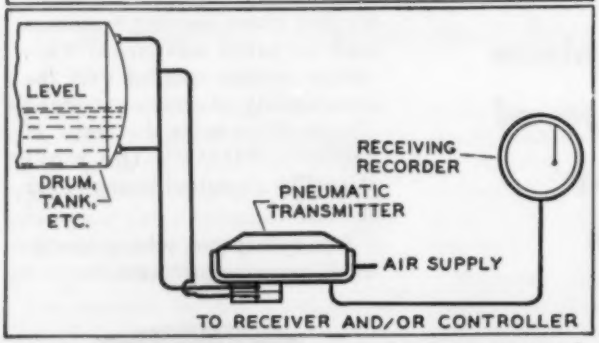

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involving the measurement of
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with pneumatic transmitters . . .

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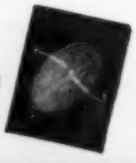

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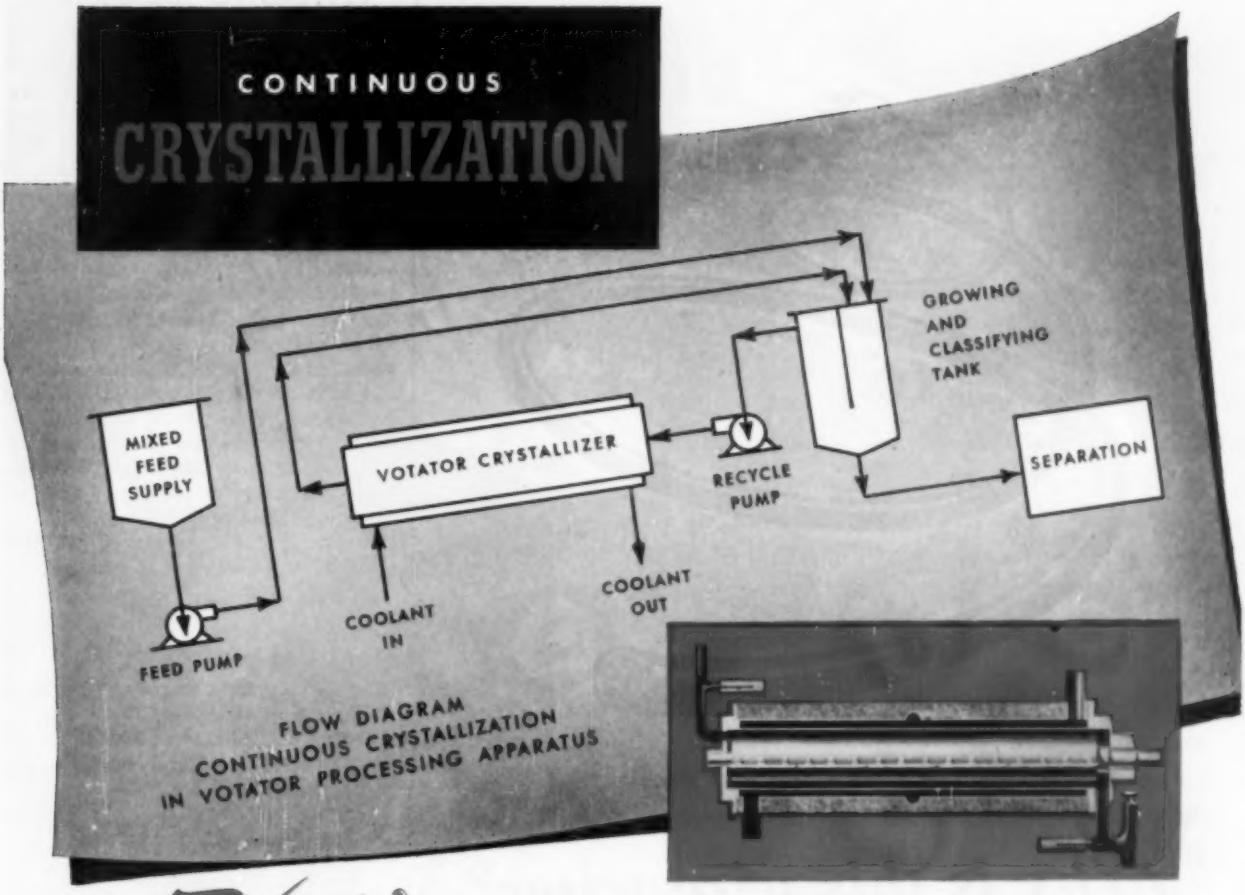

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Find out how VOTATOR Processing Apparatus can improve *your* operations. Call the nearest Girdler office today.

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GIRDLER BUILDS processing plants
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VOTATOR DIVISION:
Complete Edible Oil Plants;
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Sulfonation	Polymerization	Paper Coating
Sulfation	Textile Size	Paraffin Wax
Nitration	Shaving Cream	Synthetic Wax
Crystallization	Lubrication Grease	Resins
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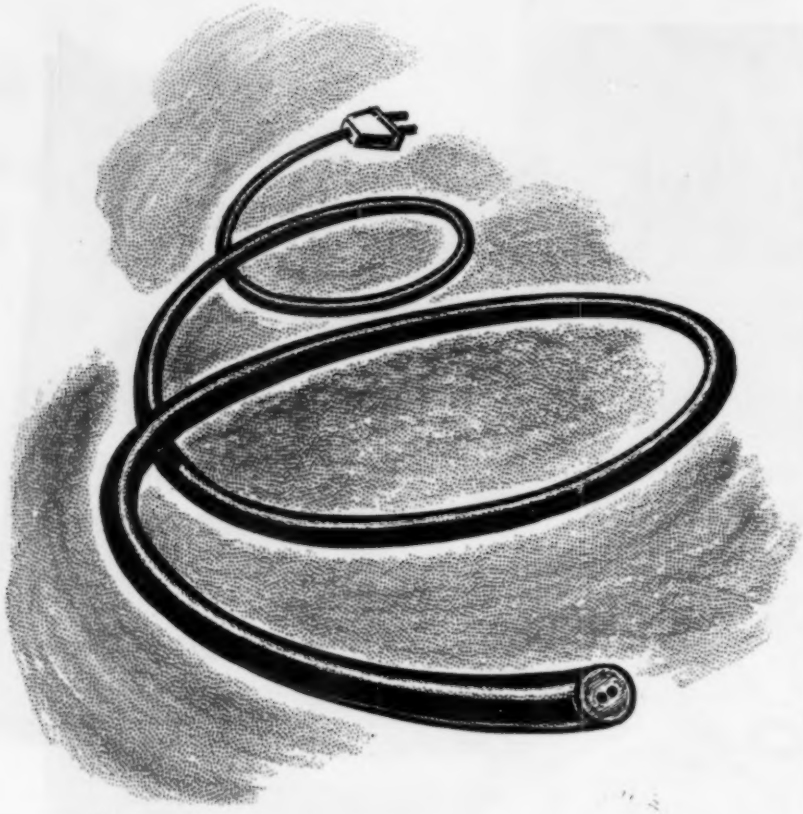
GAS PROCESSES DIVISION: New York, Tulsa, San Francisco. *In Canada:* Girdler Corporation of Canada Limited, Toronto



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Wiser and better because of a special rubber covering compound employing a **PANAREZ** hydrocarbon resin.

In GRS electrical wire covering applications, **PANAREZ** resins produce stocks which are economical, smooth, glossy, easy processing and fast extruding. They provide excellent color and color stability. They have low specific gravity. They enhance such properties as tensile strength, elongation, tear resistance, abrasion resistance, electrical characteristics and aging qualities.

Applied in many ways in the compounding of synthetic rubbers, **PANAREZ** resins are helping produce better products, *and at the same time effect decided economies.*

Whether your business has to do with wire, shoe soles, belting, floor tile, hose, insulators or some other products, we welcome the opportunity to work confidentially with you on your particular problem. For full information write or wire Dept. CE.

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Hydrocarbon resins	Hydrocarbon drying oils	Aromatic solvents

LETTERS TO THE EDITOR

(*Continued from page* 8)

equipment selection under way. Later I'll help in the planning of a new unit operations lab. All of this is giving me a chance to dig around in the journals much more than my usual schedule at Penn has permitted. If anything, it's made me appreciate our U. S. journals all the more.

As to our life here—the temperature has mostly been 20-30° F. The mountains which surround us are 1500-2000 ft. high and have had snow on the top since Oct. 15. Now we have 4-5 inches of snow here in the valley but 10-15 inches up on the mountains where we go skiing. It now appears that Norwegians are not born with skiis, but only get them on their 1st birthday. At 6-8 years they are really expert. However, there are duffers of all ages, too, so we don't lack company. . . .

M. C. MOLSTAD
[University of Pennsylvania]
Trondheim, Norway

Operation New Look

I think you did a fine job of setting up the article [Mixing of Finely Divided Solids, S. S. Weidenbaum and C. F. Bonilla, January, 1955] by Dr. Weidenbaum and myself; it looks very attractive.

C. F. BONILLA
New York

MARGINAL NOTES

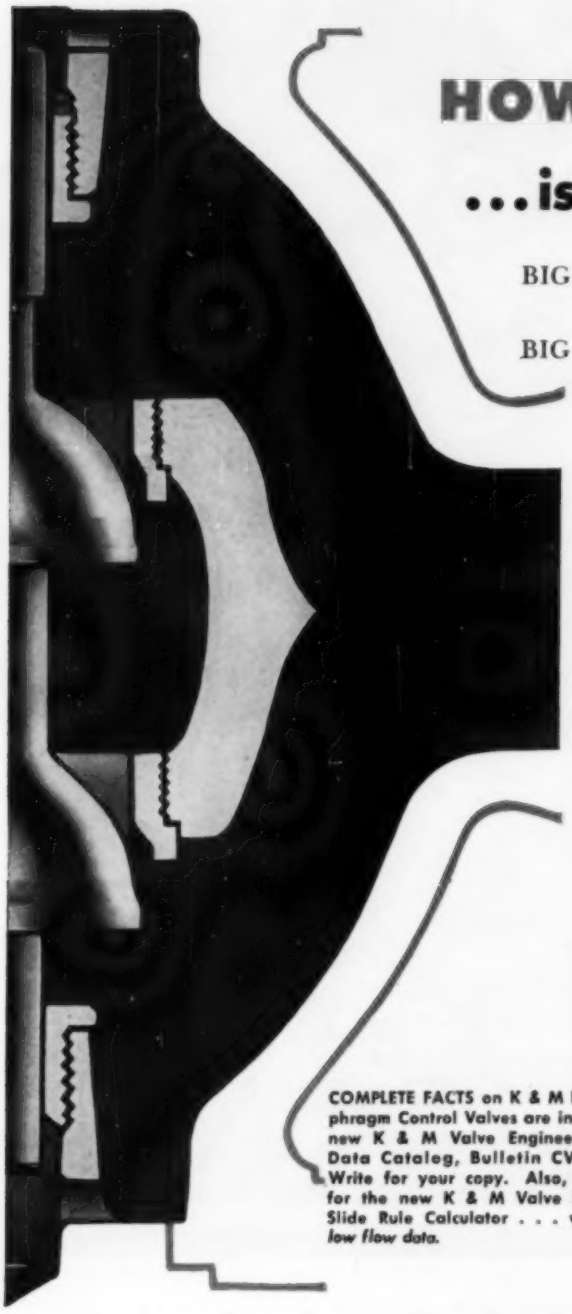
Steel Structures Painting Manual. Vol. I, Good Painting Practice. Joseph Bigos, Editor. Steel Structures Painting Council, Pittsburgh, Pa. (1954), 423 pages, $6.00.

Reviewed by M. L. Monack and W. R. Myers, Engineering Department, Dupont Co., Inc., Wilmington, Del.

"Good Painting Practice" is the first of a two-volume manual under preparation by the Steel Structures Painting Council, which is sponsored by nineteen technical societies and associations. One of the stated purposes of this Council is "to make more effective and more economical the protection of steel surfaces." A great stride was taken toward the accomplishment of this goal with the publication of this work.

Volume I, which covers the general fields of surface preparation and application methods, is arranged in 18 chapters, prepared by authoritative writers. Basic theory, specifications, surface preparation, coating applications, inspection, maintenance, performance records, and costs are treated in a practical and forthright manner.

(*Continued on page* 18)



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...is a K & M six-inch valve?

BIG enough to pass 500 gpm of cold water through the valve body at a constant drop of one pound pressure.

BIG enough to provide the largest flow coefficient available in a standard six-inch diaphragm control valve.

Body flow passages of all K & M valves, for example, actually average 140% of cross-sectional pipe area. There's more space for fluid to flow . . . smoothly, freely and without turbulence. Frequently a smaller nominal size K & M Valve provides sufficient capacity to satisfy requirements that formerly called for a larger, more expensive valve.

Inner valve open areas, on the other hand, average only 80% of cross-sectional pipe area. Therefore, flow restrictions occur principally across the inner valve . . . where the restriction is controllable throughout the entire range of valve stem travel. This K & M design often permits lower initial costs . . . always contributes to more precise flow regulation through the K & M Inner Valve.

COMPLETE FACTS on K & M Diaphragm Control Valves are in the new K & M Valve Engineering Data Catalog, Bulletin CV53. Write for your copy. Also, ask for the new K & M Valve Size Slide Rule Calculator . . . with *low flow data.*

C_V COMPARISON TABLE

Valve Size	K & M	Valve B	Valve C
¾"	10.9	8.4	8
1"	17.3	14.9	12
1½"	39.1	33.2	28
2"	61	57	48
2½"	97.7	71.0	72
3"	150	116	100
4"	219	197	165
6"	500	364	360

Based on the maximum C_V at rated travel through the valve body. From manufacturers most recent slide rules or tables.

diaphragm control valves

KIELEY & MUELLER, INC.

K&M

Valve Makers Since 1879

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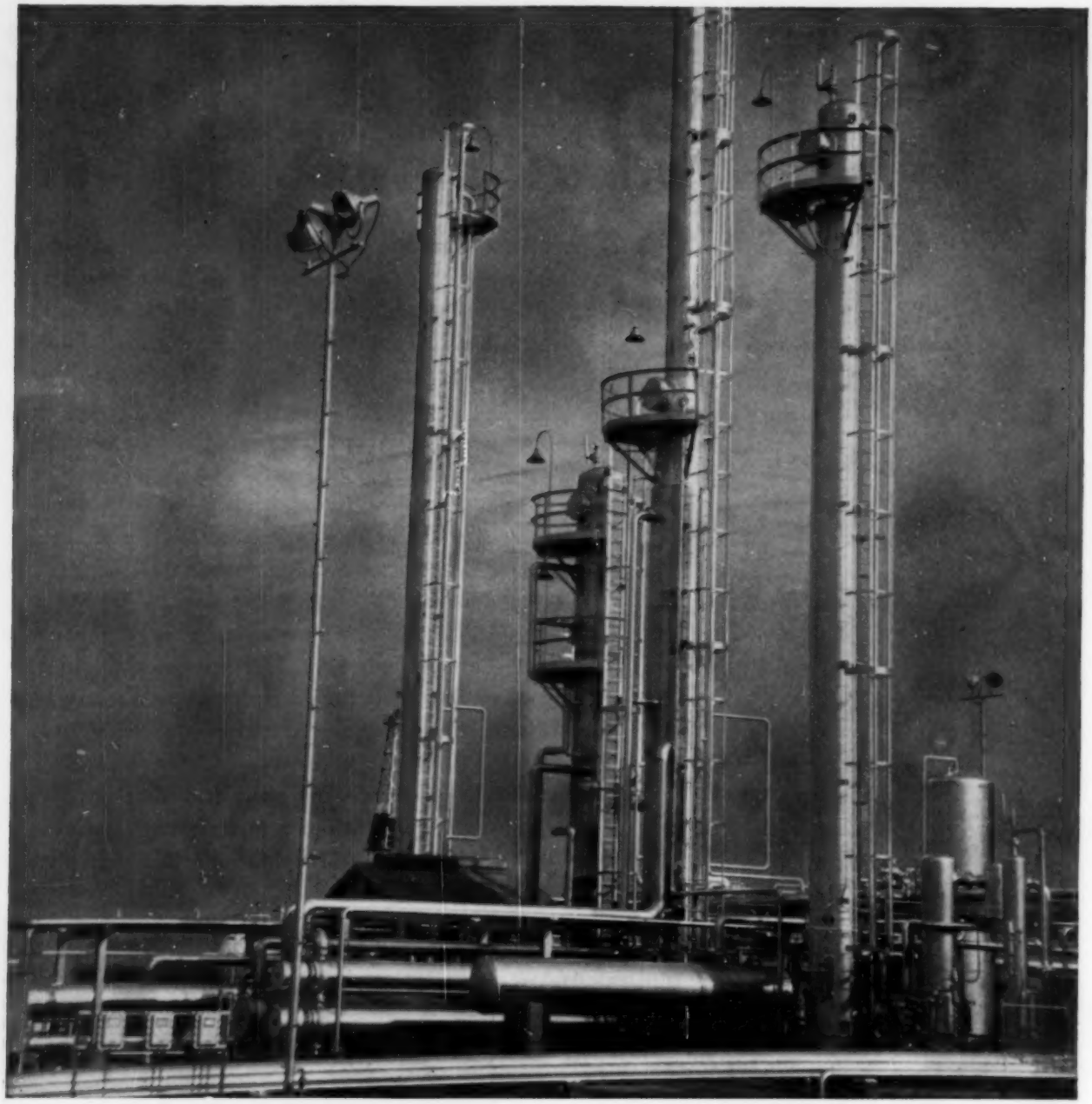
Middletown, New York



Unibestos means stronger, longer lasting pipe insulation

Amosite...the South African asbestos with long, strong, resilient fibers gives Unibestos Pipe Insulation greater strength and superior insulating ability. Built for durability, Unibestos resists both vibrations and shock, and is unaffected by most acid and chemical fumes. When lines must be relocated and replaced, Unibestos can be removed and reapplied with little or no loss of material.

Single Layer Construction Cuts Installation Costs

Unibestos is easily handled—can be cut, mitered, for quick installation, requiring little pointing of joints. Unibestos reduces scaffolding needs, and speeds completion of job.

Unibestos Reduces Heat Loss

Tests prove that Unibestos *single-layer* pipe insulation provides greater protection against heat loss than other nonfibrous double-layer insulations.

STANDARD PRODUCTION SIZES

Unibestos Pipe Insulation is regularly made in 3-foot lengths for pipe sizes from ½" through 24", in standard thicknesses through 5". Unibestos Block Insulation is made in 6", 12", 18" or 36" widths and in thicknesses from 1" through 3" in ½" increments.

For complete information, write for Descriptive Bulletin 109C.

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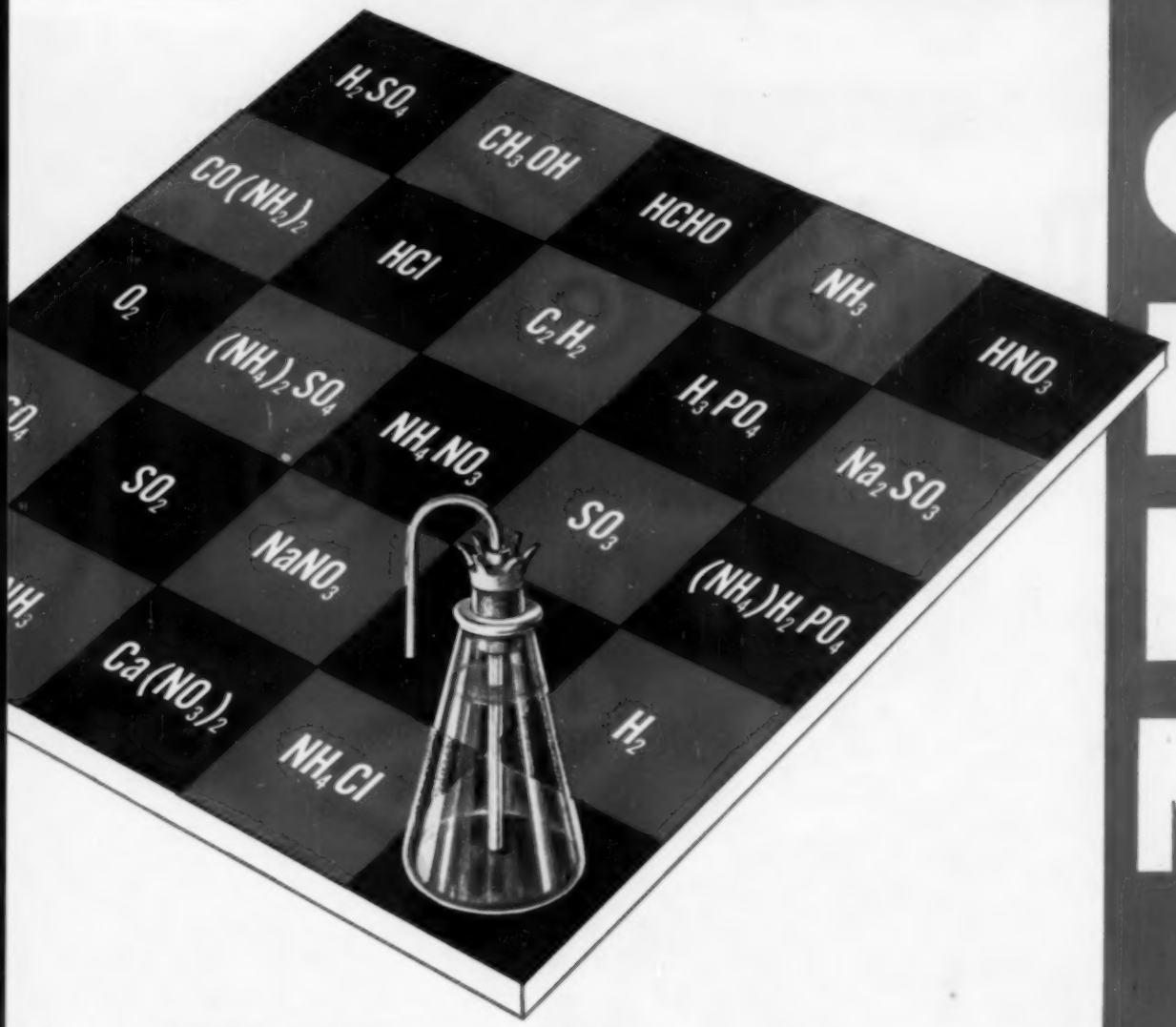

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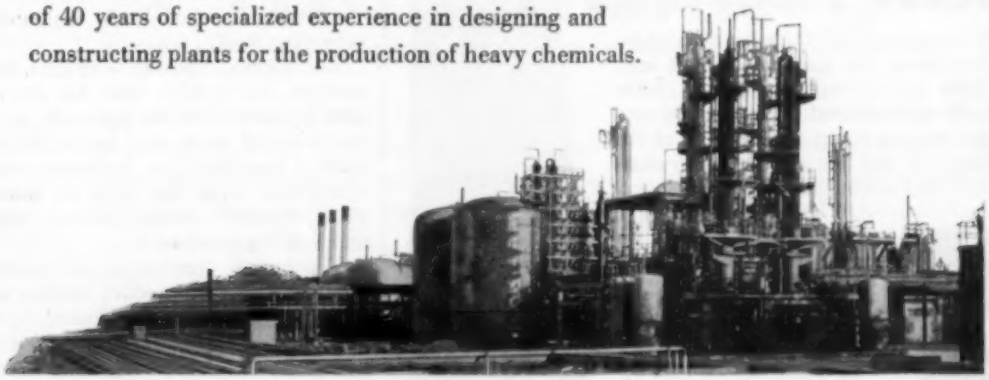

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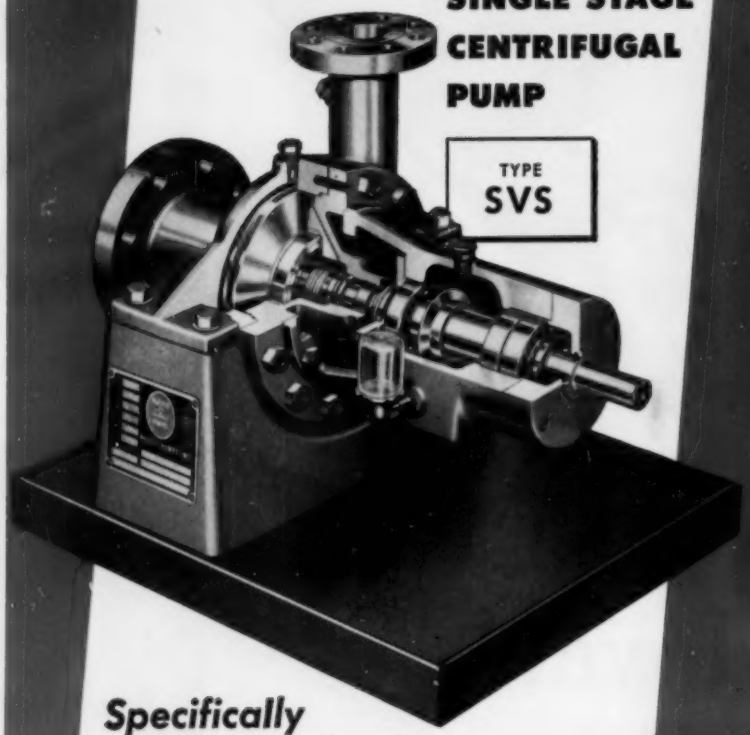

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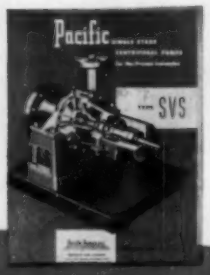
Primarily engineered for the most advantageous application of the mechanical shaft seal, Pacific Type SVS Pumps are also available for use with conventional packing. This new continuous process pump embodies all of the engineering skill and fine craftsmanship characteristic of all Pacific Pumps.



Send for new PACIFIC TYPE SVS Bulletin Number 121

Pacific Pumps inc.

ONE OF THE DRESSER INDUSTRIES

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Export office: Dresser Building, 122 E. 42nd St., New York

Offices in all principal cities

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MARGINAL NOTES

(*Continued from page* 14)

The subject matter, presented in a practical manner, is directed primarily to the men who specify, apply, and maintain paint systems. Generous references are made to standard specifications, to tools and equipment, and to safety hazards. This manual should prove valuable to project and maintenance engineers and to painter foremen and crews for checking practices, specifications, performance, cost, and for the formulation of improvement programs.

Vol. II, which is to follow, will deal primarily with coating systems.

Fiberglas Reinforced Plastics, Ralph H. Sonneborn *et al.*, Reinhold Publishing Corporation, New York (1954), 244 pages, $4.50.

Reviewed by Games Slayter, vice-president, Research and Engineering, Owens-Corning Fiberglas Corporation, Newark, Ohio.

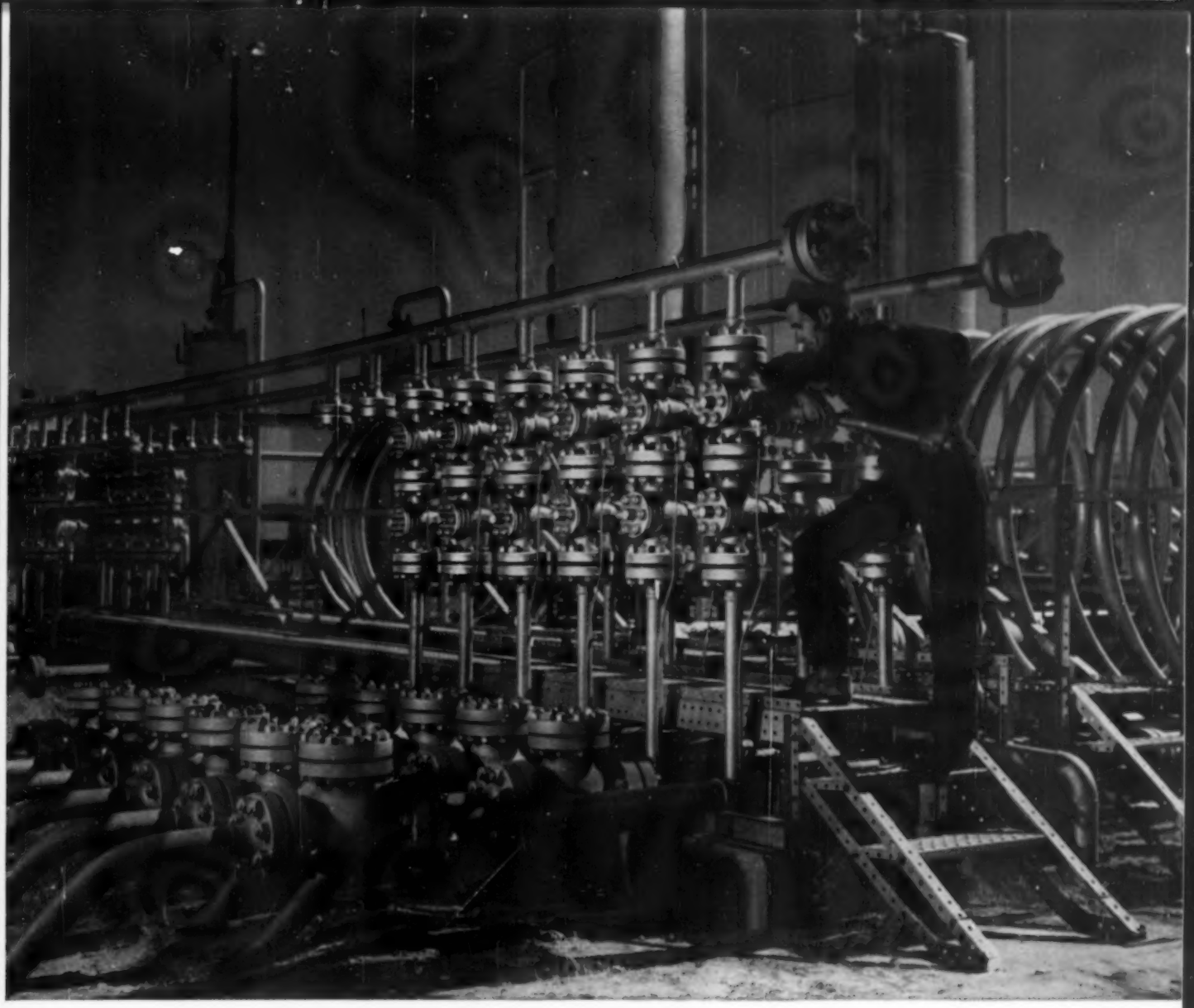
This work deserves to rank with the important technical works published in 1954, if for no other reason than its presence on the publishing scene. In essence, it marks a milestone in the dynamic growth of a new industry representing the first complete and comprehensive text ever published on the subject of reinforced plastics, and coincides with the tenth anniversary of the development of Fiberglas-reinforced polyester plastics. In this new volume we have, for the first time, a carefully conceived compilation of presently available knowledge on a fascinating, difficult, and many-sided subject.

This is definitely not a one-man effort. In the planning and writing of the book, Mr. Sonneborn called on the talents of the foremost authorities in the rapidly expanding field.

The volume is replete with data, suggestions, and specific tools for the design engineer. Yet its approach is not too technical to be read by the layman with a penchant for becoming more conversant with the field of fibrous glass, catalysts, resins, presses, molds and molding compounds.

The logical presentation of material is a boon to all prospective readers, and particularly to those uninitiated in the realm of plastics. After spelling out the nature and uses of Fiberglas reinforced plastics, there is complete discussion of materials, manufacturing processes, secondary operations, inspection and testing, properties, design methods, and applications. Also included are two chapters on design.

(*Continued on page* 24)



Profit-Making

Lubricating a Rockwell-Nordstrom valve periodically is not just another maintenance item; it's a profit-making investment in low-cost operation. The advantages are the same as those you get from lubricating your automobile engine: increased efficiency and longer life at lower end-cost.

Rockwell-Nordstrom lubrication saves you money in three important ways: 1. eliminates wear of metal-to-metal friction; 2. provides a constantly renewed seat for leak proof sealing; 3. allows the plug to be hydraulically jacked for instant operation when necessary.

Today's Rockwell-Nordstrom quality is the result of forty years of leadership in building the most complete line of lubricated plug valves and plug valve lubricants in the world. Why not use that unequaled experience to cut *your* valving costs! Rockwell Manufacturing Company, Pittsburgh 8, Pa.

ROCKWELL-Nordstrom VALVES

LUBRICANT SEALED FOR POSITIVE SHUT-OFF

Put New Profits in Production

Is controlling the flow of liquids, solids, gases or slurries part of your production problem? Rockwell-Nordstrom valves will do a *better* job —at lower cost—than any other valve you've ever tried.

Pressure lubrication that forms the leak proof seal in Rockwell-Nordstrom valves has the same importance whether your flow problem is cement slurries or light hydrocarbon gases. Quarter turn operation gives you precision control whether you're batching chemicals or measuring fuel. And tough lubricant film protection of metal working surfaces, plus unexposed seating areas, means longer valve life whether your lines carry pulp liquors or synthetic rubber.

You can't buy a more dependable, more efficient valve than Rockwell-Nordstrom—or one that will cost you less to use. Write for complete information today. Rockwell Manufacturing Company, Pittsburgh 8, Pa.

ROCKWELL-Nordstrom VALVES

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WHERE SHOULD YOU USE KARBATE BRAND IMPERVIOUS GRAPHITE PROCESS EQUIPMENT?

ANSWER: *Wherever you want:*

- Corrosion resistance
- Freedom from metallic contamination
- Immunity to thermal shock
- Low first cost and maintenance
- Ease of alterability and repair

Manufactured Only By National Carbon Company

"Karbate" impervious graphite equipment is often installed in services where other materials have proved inadequate. The same properties that enable "Karbate" products to meet these severe requirements can give you substantial savings in virtually *all* service conditions. On the basis of price, maintenance-cost and increased service life, "Karbate" products merit your first consideration *wherever* corrosion is a factor.

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The term "Karbate" is a registered trade-mark of Union Carbide and Carbon Corporation

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Cascade Coolers—Catalog Section S-8820

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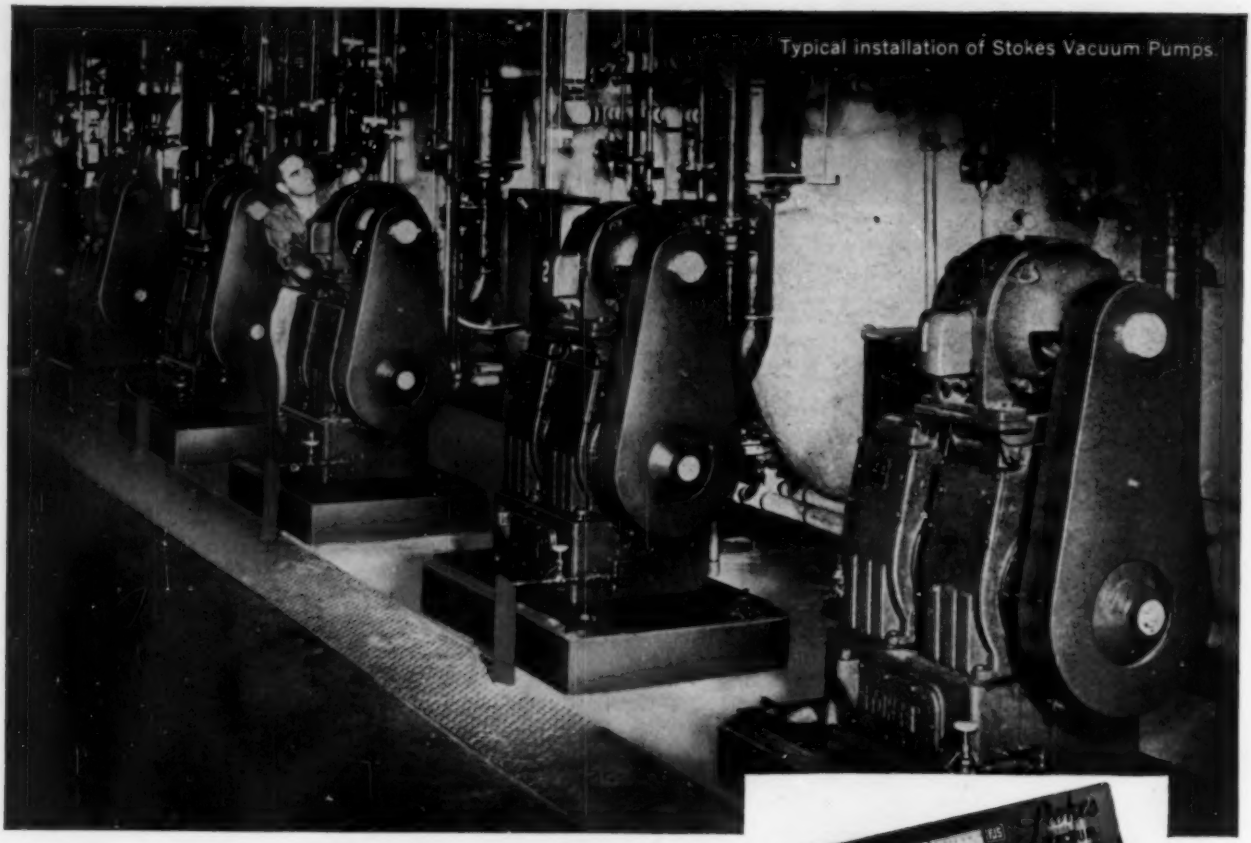

Typical installation of Stokes Vacuum Pumps

Stokes Microvac Pumps... basic to Vacuum Processing

High volumetric and mechanical efficiency make these famous pumps economical and reliable units in any vacuum system.

Capacities of Stokes Microvac Pumps run from 15 to 500 cfm . . . pressures to 10 microns absolute. Power consumption is low and the top-mounted motor contributes to compact design requiring minimum floor space.

Lubrication of the four moving parts (including the exhaust valve of corrosion-resistant Teflon) is fully automatic. There are no stuffing-boxes or grease-fittings, and no packing.

Parts are precision-finished, standard and interchangeable. Freedom from wear assures years of trouble-proof service.

Stokes is the only manufacturer of equipment for complete vacuum systems, including Microvac mechanical pumps, Ring-Jet Diffusion and Booster pumps, McLeod Gages and Vacuum Valves.

Consult with Stokes on the application of vacuum to drying, freeze-drying, impregnating, extraction, solvent recovery, evaporating, vacuum metallizing, and to other purposes for which vacuum deserves exploration.

F. J. Stokes Machine Company,
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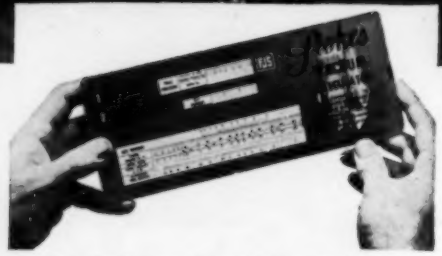

Send for new Vacuum Calculator for rapid slide-rule calculations. Includes standard ABCD log scale. Also send for Catalog 700, "Stokes Microvac Pumps for High Vacuum," with copious reference material.

Send for copy of a new handbook "How to Care for Your Vacuum Pump." (Bulletin No. 755). Contains many valuable suggestions about installation, starting, servicing, trouble-shooting, and helpful "Do's" and "Don'ts" on vacuum pumps and systems.

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ENGINEERS of unusual ability can find a future in design and technical sales with Stokes. Write for information.

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WHEN MALTED MILK WAS FIRST INTRODUCED

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WAS MAKING INDIVIDUALIZED CHEMICAL EQUIPMENT

Good news travels quickly—and only a few short years after its introduction, malted milk had become one of our favorite national refreshments. Yet—even before the first malted milk tablet was enjoyed—word-of-mouth recommendations by chemical manufacturers had already established KOVEN as one of America's foremost steel fabricators. For over 70 years now, leading chemical plants have been achieving faster, more economical output with efficient KOVEN Individualized Equipment—built to their exact needs. See how KOVEN's accumulated skills and vast resources can help you in your race against time and costs. Call or write for a consultation—no obligation. Send for Bulletin #550.

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KOVEN equipment in all metals and alloys include: High pressure vessels, extractors, mixers, stills, kettles, tanks, stacks, breechings. Shop and field erected storage tanks. High vacuum testing.

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THREE RING PERFORMERS

...the O-ring stem seal is one of the special features that make Hoke valves star performers in the fluid control field. Hoke needle, toggle and metering valves are designed with Hycar® O-rings because of this kind of performance:

...they seal leak-tight (these valves will pass high vacuum tests right off the production line!)...they stay leak-tight, you can forget about periodic packing adjustments...and they offer finger-tip control with no packing friction or binding.

Hoke pioneered the O-ring in small valve applications and you'll benefit from this engineering leadership in using Hoke valves on your test equipment, in the laboratory or for instrument air lines.

May we send you catalog information on these three ring* performers?

*(O-rings, that is)

HOKE
HOKE INCORPORATED
Fluid Control Specialists
143 S. DEAN STREET, ENGLEWOOD, N. J.

MARGINAL NOTES

(*Continued from page* 18)

Attractive typography and judicious use of illustrations make the book extremely readable. It is further supported by a glossary of terms and an extensive bibliography.

Symposium on Odor. Special Technical Publication No. 164. American Society for Testing Materials. Philadelphia, Pa. (1954), 88 pages, $2.25.

The papers and discussions in this Symposium on Odor were presented at the tenth and fifteenth sessions of the fifty-seventh annual meeting of the American Society for Testing Materials held in Chicago, Illinois, June 15, 1954. Six papers are included. The Society states that the odorous properties of materials have been recognized as being fruitful subjects for study, and that nomenclature, measurements, and control in this field all present unique problems.

The Sulphur Data Book. William N. Tuller. McGraw-Hill Book Company, Inc. (1954), 143 pages, $5.00.

Reviewed by Wayne C. Edmister, California Research Corporation, San Francisco, Calif.

Useful charts and tables of data on sulfur are concisely presented in this book. There are five sections dealing with the nature of sulfur, physical and chemical properties, reaction thermodynamics, solubilities, and methods of analysis.

Reference Work on Pumps

A complete and authoritative reference book on the vertical turbine pump industry has been issued by Johnston Pump Company. This 392-page manual discusses pump selection for hot, volatile, viscous and corrosive fluids, applications, engineering formulas and data. The development of ground water resources, geology, drilling methods, well-logging, construction, design, and performance characteristics of vertical turbine, mixed flow and propeller pumps, and many other factors are analyzed. Specific papers have been contributed by leading authorities.

This indexed work of the vertical pump industry in one volume furnishes the foundation upon which the engineer, regardless of his field, may base his premise and evaluate his individual pumping problem.

The book is priced at $10.00 and is obtainable from Johnston Pump Company, 3272 E. Foothill Boulevard, Pasadena, Calif.

SAFETY

is a vital part of our construction service

Several factors combine to make a Blaw-Knox Chemical Plants Division construction job move smoothly, speedily, to a trouble-free completion. One of these is *safety* in construction activities.

Here the Chemical Plants Division has an outstanding record, which is recognized by safety awards such as these:

- **Associated General Contractors of America**
  14,090,000 man-hours awarded 1953 *First Place* in Group A, which covers all member contractors doing over 500,000 man-hours of work annually.
- **National Safety Council Awards of Honor**
  (for work without a lost-time accident)

  4,112,095 man-hours for the DuPont Company at Charlestown, Indiana, from December 1952 to May 1953.

  1,649,574 man-hours for the Atomic Energy Commission at the Hanford Ordnance Works, Richland, Washington, from September 1953 to January 1954.

  1,233,097 man-hours also at Hanford Ordnance Works, between July and September 1954.

But safety at Blaw-Knox does not start or end with construction. Safety provisions on all Chemical Plants Division projects are made a most important part of every stage of planning, designing and selecting of materials and equipment, and they extend beyond the period of construction. Safety records in plants designed and erected by our engineers, as an example, are among the best to be found anywhere.

Chemical Plants Division is the engineering-constructing organization of the Blaw-Knox Company which designs and builds plants for many industries, including chemicals, detergents, drugs, fats and oils, fertilizers, foods, gases, low temperature, nuclear energy, petroleum, petrochemicals, resins and plastics, synthetics and wood utilization. Let us help you solve your planning, engineering and construction problems . . . on all or any part of your project.

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Chemical Plants Division
Pittsburgh 22, Pennsylvania
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CRANE VALVES have longest life in this sulphur pit

THE CASE HISTORY— Leakage in steam lines to sulphur pit heating coils was hindering operations at International Minerals & Chemical Corp. plant at Lockland, Ohio. The condition prevented servicing of traps, strainers and the heating coils.

Valves that leaked beyond repair after as little as 6 months' service were the source of the trouble. Their seating as well as packing failed to stand up.

In January, 1953, after trying other types, Crane 14½P Plug Type Disc Globe Valves were installed. Today, they're still giving excellent service at low cost. Recently, the steam piping was completely replaced—the Crane valves were repacked and put back in the lines. That's all the maintenance they needed after 18 months in this severe service.

Crane 150-Pound No. 14½P Plug Type Disc Brass Valves

Long-wearing, hard seating surfaces in a rugged, well-proportioned, Crane-designed body make these valves exceptionally suited for steam and other severe services. Consult your Crane Catalog or your Crane Representative.

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VALVES • FITTINGS • PIPE • PLUMBING • HEATING

CRANE'S FIRST CENTURY . . . 1855-1955

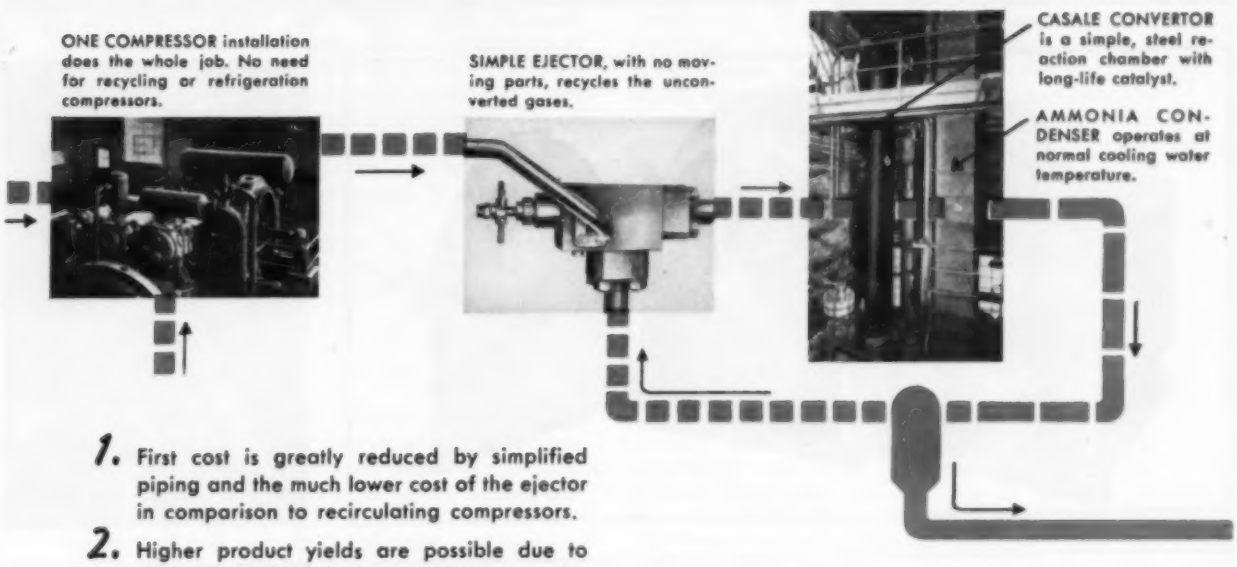
six reasons why

HIGHER PRESSURE

means

LOWER COST

in Casale Ammonia Synthesis


ONE COMPRESSOR installation does the whole job. No need for recycling or refrigeration compressors.
SIMPLE EJECTOR, with no moving parts, recycles the unconverted gases.
CASALE CONVERTOR is a simple, steel reaction chamber with long-life catalyst.
AMMONIA CONDENSER operates at normal cooling water temperature.

1. First cost is greatly reduced by simplified piping and the much lower cost of the ejector in comparison to recirculating compressors.
2. Higher product yields are possible due to minimizing of the leakage which cannot be avoided when using recirculating compressors.
3. Oil contamination into the passing gases is eliminated. This condition is an inherent disadvantage of mechanical compression systems.
4. A simplified heat exchanger built into the reaction chamber eliminates outside heat exchanger and simplifies piping.
5. High operating pressure permits production of liquid anhydrous ammonia at normal cooling water temperature.
6. High operating pressure also provides greater reaction tolerance for carbon monoxide and oxygen contaminants in the synthesis gas.

THE CASALE process has been proved in more than 40 synthesis plants with a combined capacity of over 5,000 tons per day. In all cases, the operating pressure of 9,000 to 12,000 psig has been a definite economic advantage — contributing to greater economy of installation and operation and maximum yields of pure, liquid anhydrous ammonia. Our long experience in this field is at your service. Write for Bulletin No. 0-54-1. *Foster Wheeler Corporation, 165 Broadway, New York 6, N. Y.*

FOSTER WHEELER

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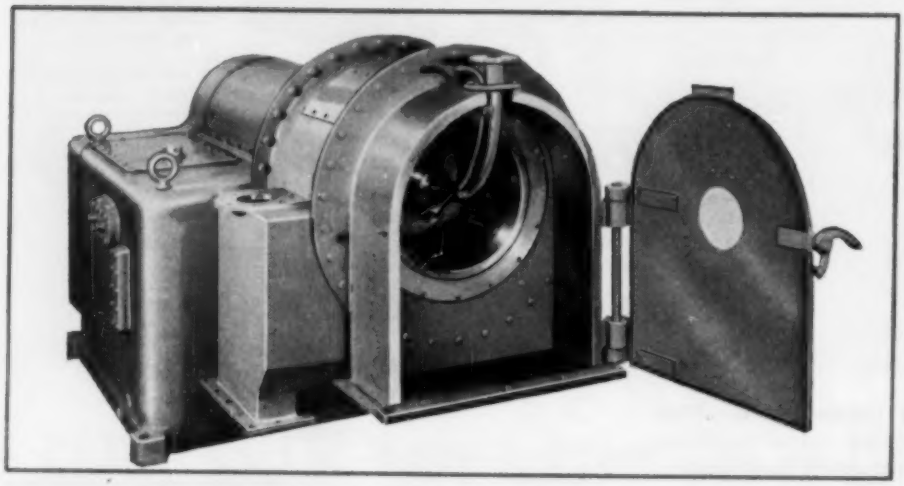

B-P TYPE S CONTINUOUS CENTRIFUGAL

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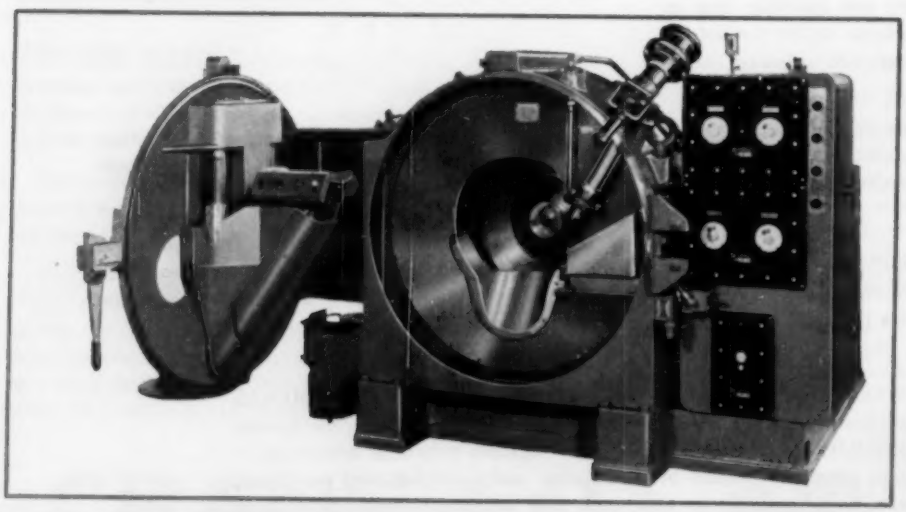

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CEP *trends*

ISOCYANATES

A new chemical that has both the rubber industry and the chemical industry agog is something that will bear watching. The newcomer is isocyanate, otherwise known as polyurethane. It can be made into a foam that is expected to be a rival to foam rubber but can also be made into a structural foam that is hard and tough.

But this appears to be only the beginning of a good many major uses. One leading chemical man comments, "this represents a fundamental turn in the whole synthetic rubber picture." This is because isocyanate rubbers are greatly superior to both natural and to present synthetic rubbers in a number of physical properties, and therefore, the isocyanates are pretty sure to force their way into the picture even though at present they are more costly.

Strong evidence of future horizons for these materials is the fact that every big rubber company, like U. S. Rubber, Goodrich, Firestone, and Goodyear are feverishly working at research. They are not only working on the foams and planning to produce them but they are also working on tires.

Isocyanate tires would wear much longer than present types—some say they might even outlast the life of the car. However, there are a good many technical problems to be solved before tire production would be in sight. There is the problem of adhesion to the carcass, and of compounding, for example.

Early in March the large Allied Chemical & Dye Corp. announced it would build a multimillion dollar plant to make the materials. How big the plant will be is still held secret. So far, Allied has been producing only in pilot plant quantities. Du Pont has been in the field also on a small scale for some time. Monsanto Chemical Co. has formed a new subsidiary, Mobay Chemical Corp., in partnership with the German Bayer Company.

So far, production of the isocyanates is negligible. No exact figures are available, but authorities in the business guess that current output is no more than 1 million to 2 million pounds yearly. However, when new plant capacity now building comes in some time in 1956, output is expected to jump to the 20 million to 30 million pound level. If the materials live up to hopes, even this could be just a start. Costs are still high. Present price is around $1.40 a pound, which represents a decrease from $4 a pound in 1953, but it is probable that further important reductions can be made when volume grows larger.

Monsanto's new plant will be at New Martinsville, West Virginia, and will have a capacity of "several hundred tons a month." If *several* means 300 tons, this would indicate a capacity of around 7 million pounds or more yearly for this plant alone.

Some authorities believe that when the isocyanates really get rolling they will take over 75% or more of the present foam rubber market. Of course, this will not bother the rubber companies who are perfectly happy to use any good material.

Isocyanates have gone much further in Germany than they have here. Some uses already include table mats, sponges and mops, brushes, mattresses and upholstery, sound proofing and insulating. At present Germany is exporting the chemical to this country also.

In this country first uses will probably be in direct competition with foam rubber in mattresses and upholstery. Seats in automobiles and in airplanes are a good prospect. One big advantage to plane makers, which might make them willing to pay a premium, is that seats made of the isocyanates weigh only about half as much as natural or synthetic rubber foam seats. They also are more fire resistant. The foam market alone is a big one to shoot at, even if other large uses for the product do not develop. Rubber foam sales are running at the rate of more than 160 million pounds yearly.

Pioneer in this country in isocyanate development has been Du Pont, which has patents going back to 1942. Other patents are held by the German Farben Fabriken Bayer A. G. Both Du Pont and Bayer have been licensing users to make the foams. Monsanto's Mobay, operating under Bayer patents, has already licensed six firms. Du Pont among others has licensed Goodyear and U. S. Rubber. Goodrich is both a producer of the isocyanates and of the foam. Carwin Co. of New Haven is another small producer of isocyanates.

Already there are a number of varied firms in the foam field. Armour & Co., the packing firm which is diversifying its business into a number of new and coming fields, is a producer. Others are Nopco Chemical Co., American Collo Corp., affiliated with German interests, and Hudson Foam Plastics Co. Nopco is making a rigid foam under patents held by Lockheed Aircraft, and the airplane firm is using the product to make radar housings for jet aircraft.

Once the business gets rolling, and adequate supplies are in sight, a large number of both large and small firms are expected to get into the business. Some basic firms in the field are reported to have had license applications from 100 or more firms who want to make the foam.

boost production
with the Ljungstrom® Air Preheater

4 *of your units*
can do
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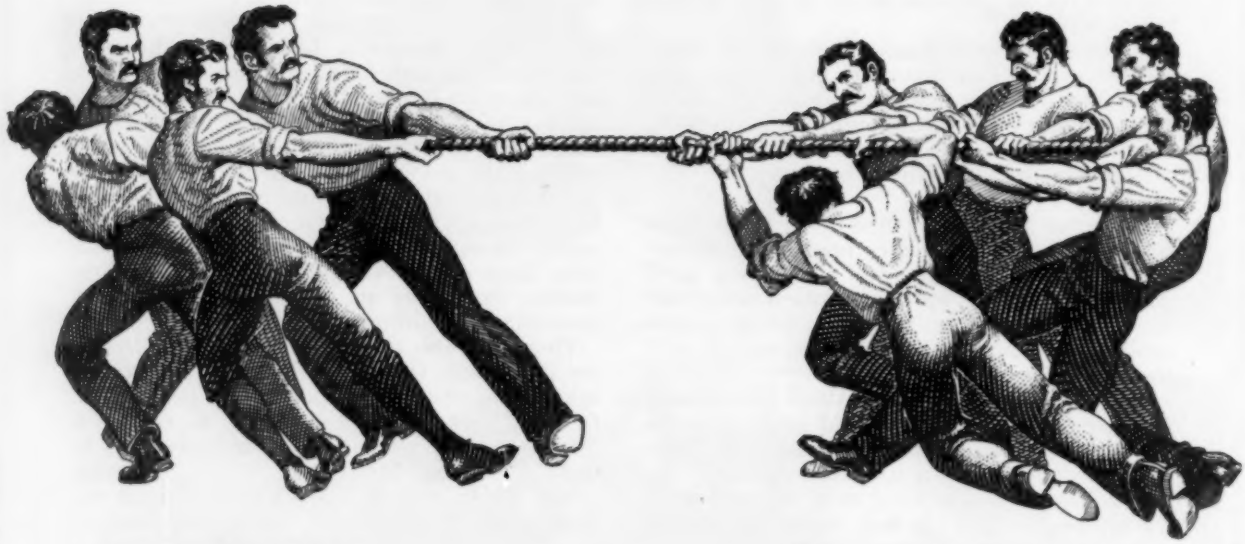
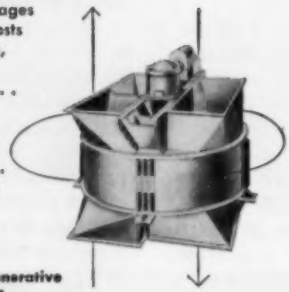


HOW FAST IS "WRITE OFF"?

In most cases, the Ljungstrom installation is quickly written off by increased capacity alone. Write-off time is even less when the other Ljungstrom advantages are considered—saves up to 20% of fuel costs . . . permits more economical furnace design, with no need for convection surfaces . . . burns many fuels you used to throw away . . . results in consistently higher through-put . . . and minimizes slag.

For more complete details on what the Ljungstrom Air Preheater can do for you . . . for an analysis of the heat recovery benefits attainable in fuel burning equipment—call or write The Air Preheater Corporation.

Wherever You Burn Fuel, You Need Ljungstrom



The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

Recover waste heat, return it to the furnace as combustion air, and you naturally generate higher flame temperatures . . . increase heat-transfer rates—*which means more through-put.*

That's why four of your present processing units can do the work of five *with Ljungstrom Air Preheaters increasing each unit's output as much as 25%.* One eastern refinery increased the continuous capacity of a pipe still from 16,000 to 18,000/20,000 barrels a day—by modernizing and including a Ljungstrom.

The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

CEP what's in this issue...

you may be interested in—

LOW TEMPERATURE PROCESSING - (p. 157) is new to many chemical engineers, not new to Air Products, the experience of which is the basis for the article on what you'll need vs. what it'll probably cost. Tonnage oxygen and nitrogen - widely used in petrochemicals and the ammonia fertilizer industries - are but two big users of low temperature processing. Other uses are mentioned.

WANT NUCLEAR WORK? - (p. 162) If you do, your chemical engineering training and experience will stand you in good stead. Besides, the opportunities will be good, according to man-of-experience Miles Leverett. But, he says, there are disadvantages - which he discusses.

VITAMIN FROM ??? - (p. 163) Chemical engineers have long been noted for their ability to make worth-while products from surprising sources. This time it's vitamin B-12 from Milorganite, the popular lawn fertilizer before it is finally dried and bagged for shipment.

FLUID COKE - (p. 167) An amazing development has taken place in the petroleum industry. Thanks to a new "fluid coking" process, it is now possible to eliminate the production of "residuum" (heavy bottoms, formerly burned) from crude - and make attractive, economically profitable products. One of these is fluid coke, which is coke, but in a form you wouldn't recognize because it is a fine powder - for which a great many commercial applications are described.

WISH YOUR ORGANIZATION CLICKED BETTER? - (p. 174) It's a complicated matter, but maybe you can get some good ideas from Hammer of Monsanto who writes on how to make a company organization plan work.

DUST - (p. 168) collection was featured last month - mention was made of a second major article by Silverman, et al... well, it's here...covers wet operation of cyclones - Reviewers have said it materially advances the know-how concerning one of the oldest types of collectors used in industry...Work was sponsored by A.E.C.

LARGE FRACTIONATING COLUMNS - (p. 189) of ten-foot diameter or so are still said to be designed on the basis of not-too-direct relationship of what takes place inside them...Some Dow Chemical engineers decided to do something about this by studying the actual performance characteristics of some of their columns by looking in through the side ports. In their paper they not only report what they saw, but also formulate new data for designers.

IF YOU'RE FINANCING A NEW PETROCHEMICALS PLANT - (p. 199) and are in the petroleum industry, chances are great you'll use a different system for compiling economic evaluations of proposed ventures, than you'd use as a member of the chemical industry...Why worry about this? Well, one good reason might be to know how good (or bad) the same venture might look to a competitor in the other industry.

PILOT PLANT EQUIPMENT - (p. 194) differs from full scale not only in size, but in versatility...This definition can be applied literally to a new pilot-scale liquid-liquid extractor developed at Penn State and commercially available through A. D. Little, Inc.

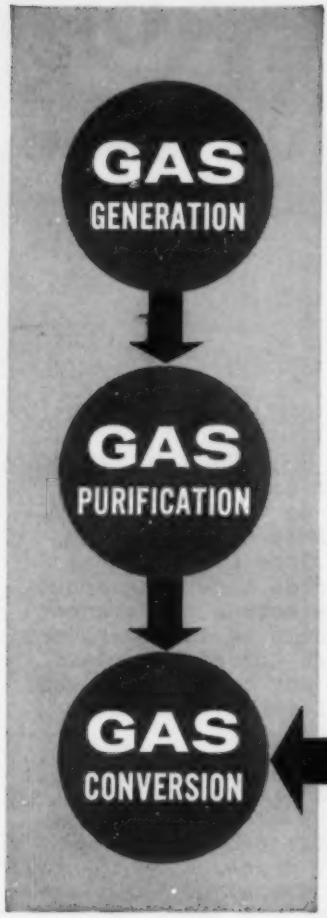
HOUSTON A-CALLIN' - (p. 33) There'll be a mighty important meeting of the Institute in Houston beginning May 1st...Come and enjoy Florida-like weather.

TITANIUM VS. CORROSION - (p. 38) Last month we outlined the wonder-metal's physical properties...This month's Sheet starts into the corrosion-resistance data you are expecting...(Don't forget it's now said to be available in quantity for chemical plant use).

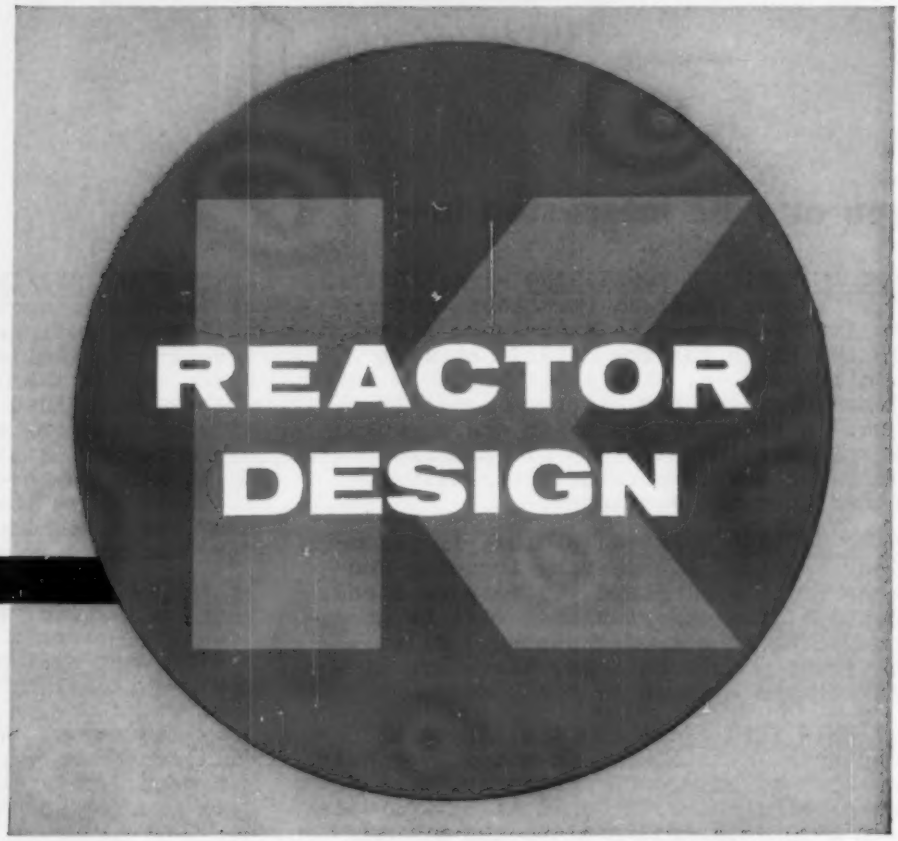
LOUISVILLE MEETING REPORT - (p. 40) If you don't see your picture, at least you'll find a map and table telling where everyone came from, and what his job classification is.

FERMENTATION - (p. 68) makes the news by making possible carload quantities of a major organic raw material - Pfizer's Itaconic Acid.

-- J. B. M.



FOR INCREASED AMMONIA DEMANDS



KEY TO HIGHER YIELDS—LOWER COSTS

IN THE PRODUCTION of ammonia, The M.W. Kellogg Company offers a number of processes for the generation and purification of synthesis gas—depending on the starting material and other local economic conditions. For the conversion phase, however, it is the Kellogg-developed, quench-type reactor which can contribute the most to increased plant capacity.

Assuring extremely accurate and flexible control of the temperature inside the catalyst mass, the Kellogg reactor eliminates the "hot spots" which cannot be averted with the conventional catalytic basket equipped with tubular heat exchangers. This in turn means, for any production rate, the gradient of temperature which gives the highest possible yields of ammonia per pass.

Capacities per day in excess of 300 tons per unit are now entirely practical with the Kellogg reactor. One such plant now being built by The M. W. Kellogg Company will have the unusually low investment cost of about fifty dollars per ton of annual capacity.

Your inquiries on ammonia or other proposed petrochemical projects are cordially invited.

M KELLOGG W

PETROCHEMICAL PROCESSES AND PLANTS

CHEMICAL PROCESS DIVISION

THE M. W. KELLOGG COMPANY, 225 BROADWAY, NEW YORK 7, N. Y.

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CEP

opinion and comment

Atomic Information

The amount of information released by the A.E.C. since the 1954 Atomic Energy Act became effective is not exactly impressive. Dean John R. Dunning of Columbia, well known as an organizer of the forthcoming E.J.C. Nuclear Congress in Cleveland, recently delivered an address in which he referred to the "log jam" of unreleased non-weapons atomic information. Calling for "Congressional action" to break the jam, he left us wondering as to just what action he had in mind.

Now we have the news that the Joint Congressional Committee on Atomic Energy has, on March 26th, appointed a "Citizens' Panel" to help speed the peaceful uses of the atom.

The Panel is made up of eight members among which is Dean John R. Dunning.

In a press conference explaining the Panel's functions, Senator Clinton P. Anderson, chairman of the Joint Committee, assured that the Panel would be "in no way competitive with the A.E.C." It was not set up to "probe or investigate the A.E.C." On the other hand, the Panel's duties would be to make a study of the A.E.C.'s activities in the peaceful field and its role as a regulatory agency for peacetime atomic work. He said the recent public hearings on atomic development had "convinced me at least that a continuing study was needed." Also, that he hoped the Panel study might erase "rough spots" in A.E.C. activities in the peacetime field.

Before the Panel meets, the A.E.C. is expected (in April) to make known which subject areas are to be declassified to permit delivery of papers by U. S. representatives before the U.N. sponsored Conference on Peaceful Uses of the Atom. If significant areas are opened up through these decisions, the program format of the E.J.C. Nuclear Congress will be broadened accordingly, benefitting the thousands of U. S. engineers and scientists who will be in attendance.

A great deal of hope exists that the A.E.C. will be able to let go of enough information to result in the setting to work of the great inventive resources of our professional groups, which are in a position to shorten materially the time still required to resolve the many problems in the way of large-scale peaceful application of atomic resources.

If this can come, so much the better. If not, then it is hoped that the Citizens' Panel will provide clarifying assistance over a matter which seems to be very much involved in sharp differences of opinion.

J.B.M.

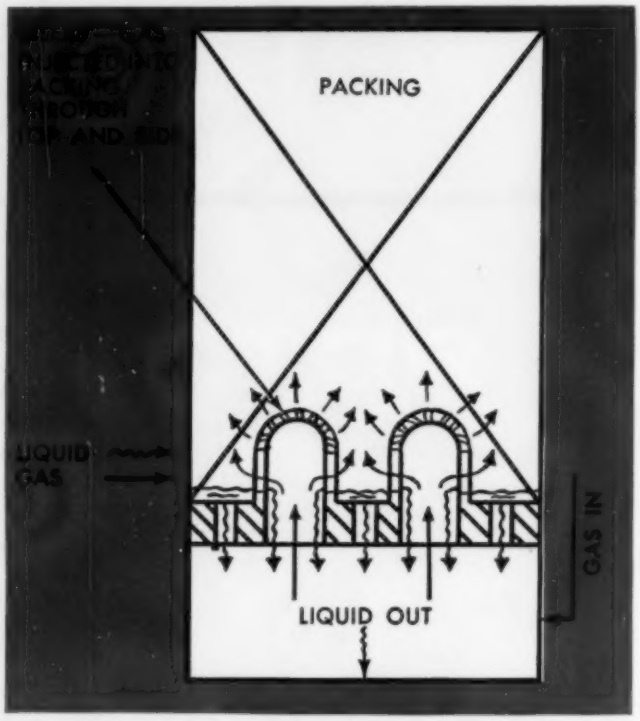
WEIR-TYPE SUPPORT PLATE* IMPROVES PERFORMANCE OF ANY DUMPED TOWER PACKING

The lower pressure drop expected from a high bed voidage can be quickly dissipated by restrictions to gas and liquid flow, set up by a limiting free area in the packing support plates.

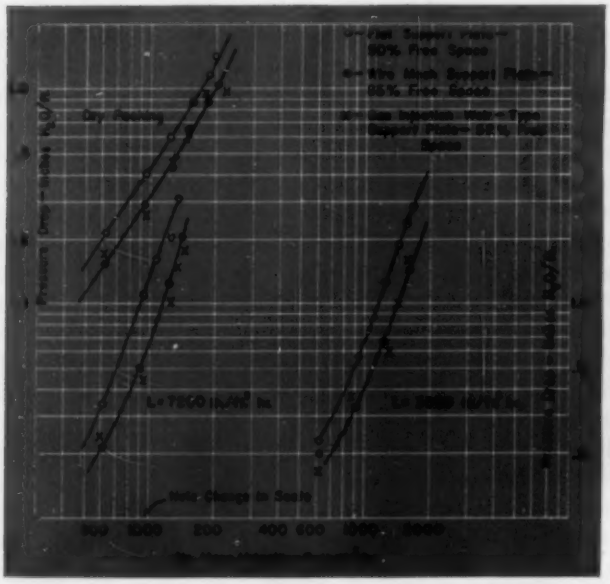
Conventional flat ceramic support plates have an actual free area of 20-30%. *Effective area,* however, is usually much less, because dumped packings, particularly in the smaller sizes, tend to block the openings in the plates.

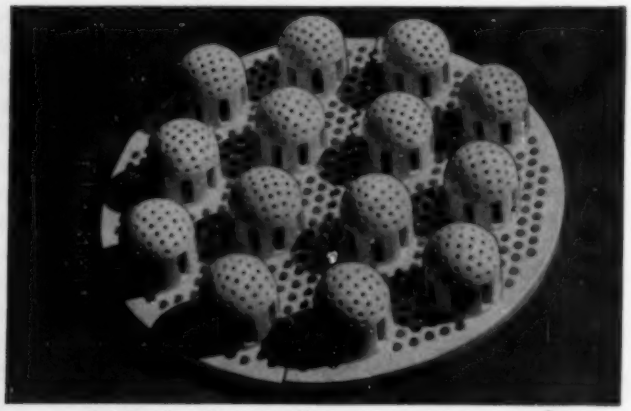
To approximately equal the voidage ordinarily encountered in a packed bed, a support plate must have a free area better than 50%, *under actual operating conditions.*

The weir-type support plate, in every size from 12″ diameter up to 60″ diameter, has better than 50% free area. Its unique, patented design minimizes any tendency of the packing to block the plate openings. Its high mechanical strength provides ample support, and, of course, its chemical porcelain body is completely acid-and-corrosion-resistant throughout (except for hydrofluoric acid and hot caustics).



In operation, the gas is actually injected or distributed into the column through the perforated hemispherical caps and through the upper portion of the slots in the risers. A major portion of the liquid ordinarily leaves the column through the openings in the base plate, but should these openings prove insufficient, and a slight head form, the overflow will escape through the bottom half of the slots in the risers.





Write for New Bulletin — on Weir-Type Support Plates

*U. S. Stoneware patent pending

THE UNITED STATES STONEWARE CO.

Process Equipment Division **AKRON 9, OHIO**

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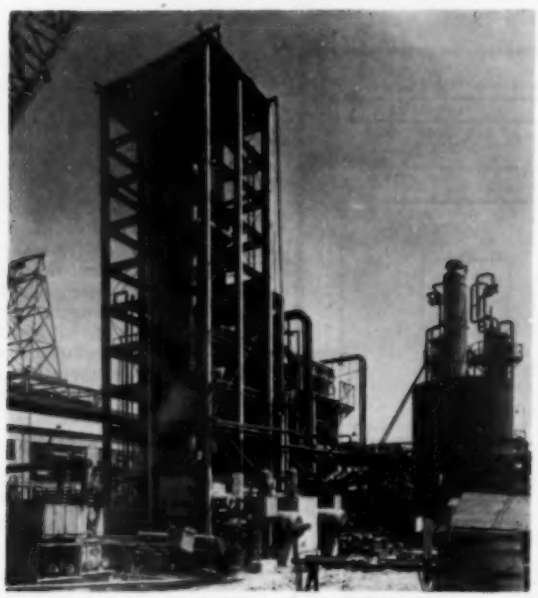
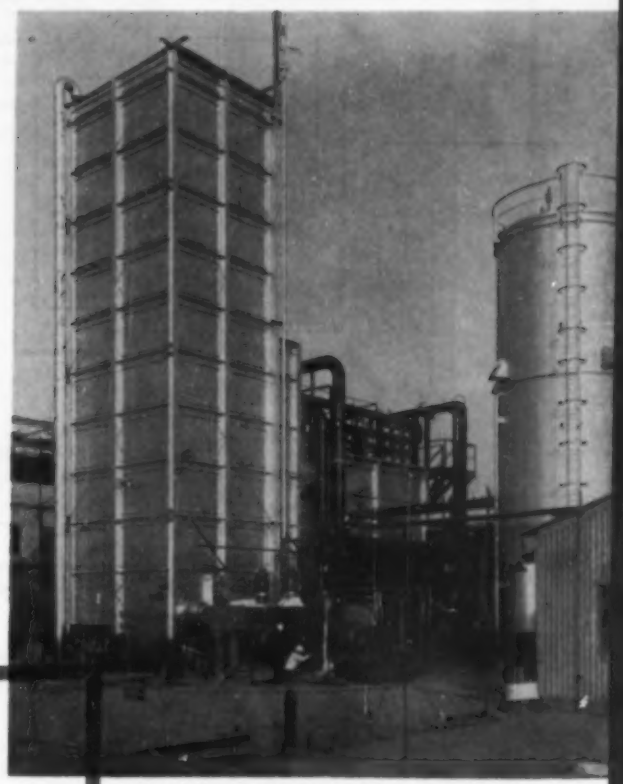


View of tonnage air separator in erection stage showing factory fabricated components in place in cold box. This plant is used by the Grace Chemical Company at its installation near Memphis, Tennessee.



View of completed plant at left after insulation has been packed and jacket panels installed. This plant also supplies liquid nitrogen for process stream purification and delivers oxygen gas at elevated pressure employing an oxygen pump to pressurize the product in the liquid state.

COST OF LOW TEMPERATURE PROCESSING

Bingham H. Van Dyke and W. J. Dougherty

Air Products, Incorporated
Allentown, Pennsylvania

A considerable amount of material in the literature has been made available through special reports and company bulletins on costs of tonnage oxygen plants. Many who try to correlate these data will notice a wide spread between the figures supplied from various sources for plants which presumably are supposed to accomplish identical end results.

Part of this discrepancy can be attributed to a lack of experience on the part of the persons preparing the data; part is due to the physical make-up or accounting basis of the organization, as it would affect plant cost; and part is due to variations in the cycles proposed. As the industry gains in "know-how" from operation of plants which have been built, cost data can be accumulated and correlated for use in the preparation of preliminary estimates.

These data can be related to such common denominators as dollars per horsepower, dollars per unit of refrigeration load, or dollars per unit of end product. A preliminary study (*1*) has recently been presented in which some process variables are related to refrigeration demand and energy requirements for a typical air-separation cycle. In making such generalizations however the user of the data must have developed an appreciation for the factors which affect the selection of a particular cycle and their effect on cost.

The purpose of this paper is to discuss some of these factors in order to create a better understanding of what low-temperature processing is, where it can be applied, of the variables which affect the selection of the process cycle for a specific problem, and the effect these variables have on cost.

Low-temperature processing involves the application of basic chemical engineering unit operations and is unique only in that it covers a temperature range extending into areas approaching absolute zero. The low-temperature area involves special problems with which many engineers have had limited experience. The most commonly used unit operations are compression of feed or process streams; expansion through a valve or engine for the purpose of lowering temperature; scrubbing for removal of CO_2, H_2S, CO, etc.; adsorption on activated alumina, silica-gel, or charcoal for removal of water, hydrocarbons, trace impurities, etc.; heat transfer for cooling, heating, recovery of refrigeration, separation of water, carbon-dioxide, and higher molecular weight components of gas mixtures being purified, etc.; distillation at temperatures of liquid air or lower; pumping extremely cold flashing liquids, such as oxygen, nitrogen, etc.; refrigeration as required to overcome the losses of irreversibility of the cycle, including warm-end temperature losses, reversing losses, heat inleakage through insulation, actual leakage of cold fluids, and refrigeration equivalent to the sensible and latent heats of liquid products leaving the system.

Typical applications of low-temperature processing include air separators to produce oxygen, nitrogen, argon and rare gases; liquid fuels and petrochemicals from natural gas, petroleum, coal, or other carbonaceous materials; ammonia synthesis gas production or hydrogen purification from such raw

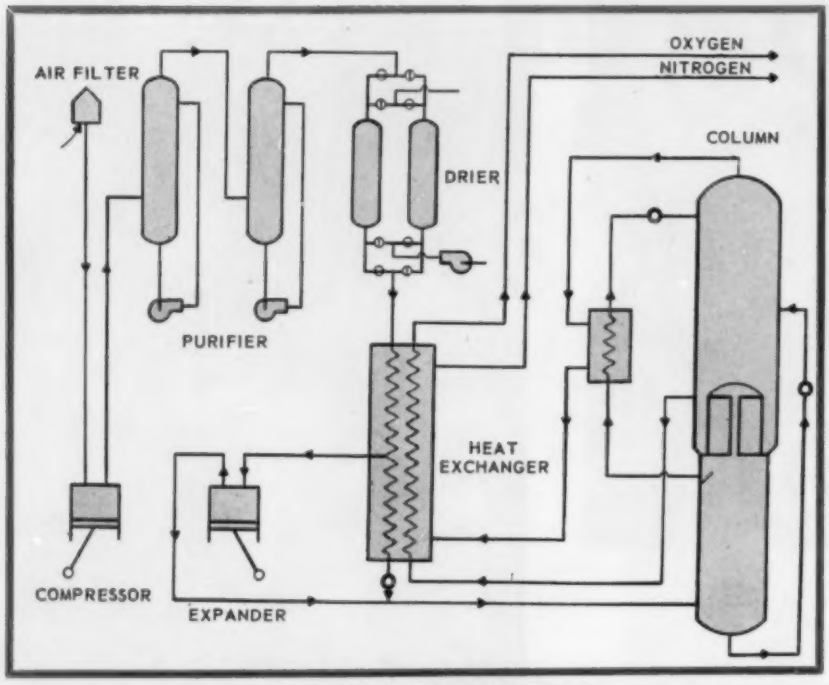


Fig. 1. Simple air separation unit.

materials as natural gas, liquid hydrocarbons, coke oven and refinery gases; purification of methane from natural gas or enrichment of natural gas by elimination of nitrogen and recovery of higher molecular weight salable by-products; liquefaction, storage and transport of natural gas; liquefaction, storage and transport of oxygen, nitrogen, argon, helium, or other valuable, but highly volatile, products which normally exist as a gas; purification of roaster gases such as recovery of liquid SO_2; argon from ammonia plant purge gas; applications in the field of nucleonics, and many others.

Figure 1 is typical of a simple cycle plant to produce oxygen and nitrogen. Caustic scrubbing followed by adsorption drying is used for air purification. A simple reciprocating expansion engine is employed to produce the low-temperature refrigeration. Product may be withdrawn as shown, all as a gas, or, by slight modification, partially as a liquid—both at essentially atmospheric pressure. The initial air-charging pressure will vary with the size of the plant from a few hundred pounds to 3,000 lb./sq.in., depending on the refrigeration requirements of the system.

In general this scheme would be used for 30 tons/day of oxygen or less. For extremely small plants, which deliver most of the product as a gas, the expander may be eliminated and all the low-temperature refrigeration obtained by Joule-Thomson effect. The product gases could be compressed to higher pressure, but when this is a requirement, it frequently proves more economical to modify the cycle as shown on Figure 2.

Here the oxygen from the column is subcooled by heat exchange against the nitrogen reflux stream to prevent flashing, then pumped to delivery pressure, which could be anything up to 3,000 lb./sq.in., or higher, gasified and warmed to ambient temperature in the main heat exchanger against the incoming air. The pump jacket is subcooled by the crude oxygen feed from the bottom of the high pressure column further to assure against flashing of the fluid being pumped.

Figure 3, although not employed by Air Products, Incorporated, as shown, illustrates one of the typical tonnage oxygen plant cycles which makes use of the reversing heat-exchanger principle. This cycle has fewer process components than the high-pressure cycle and does not require caustic scrubbing or adsorption drying. Water and carbon dioxide are deposited in the exchanger on cool-down and re-evaporated into the product nitrogen. The nitrogen and air passages reverse on a short-time cycle by means of switch-and-check valves. Because of the greater complexity and higher cost of the heat exchangers, piping, and valves, this cycle is not, in general, competitive with the high-pressure cycle in the smaller plant sizes. On the other hand, for large tonnage installations it would be lower in cost than the high-pressure cycle.

A variation of the low-pressure cycle, which is preferred by many engineers, employs reversing fixed-bed regenerators instead of heat exchangers.

Either of the high-pressure or low-pressure cycles will, in general, require the same operating labor and provide about the same degree of availability—about 95% or better on stream.

Figure 4 typifies a low-temperature system to produce ammonia synthesis gas from refinery gas, which would be 80 to 90% H_2 and which would contain varying percentages of methane, ethane, propane, and higher hydrocarbons plus some CO, N_2 and others. This is an ideal example of where the low-temperature route provides the simplest and lowest cost means for effectively producing hydrogen of maximum purity for ammonia synthesis.

The higher molecular weight constituents are separated by cool-down and condensation in a heat exchanger. The final purification is accomplished by scrubbing or fractionating with

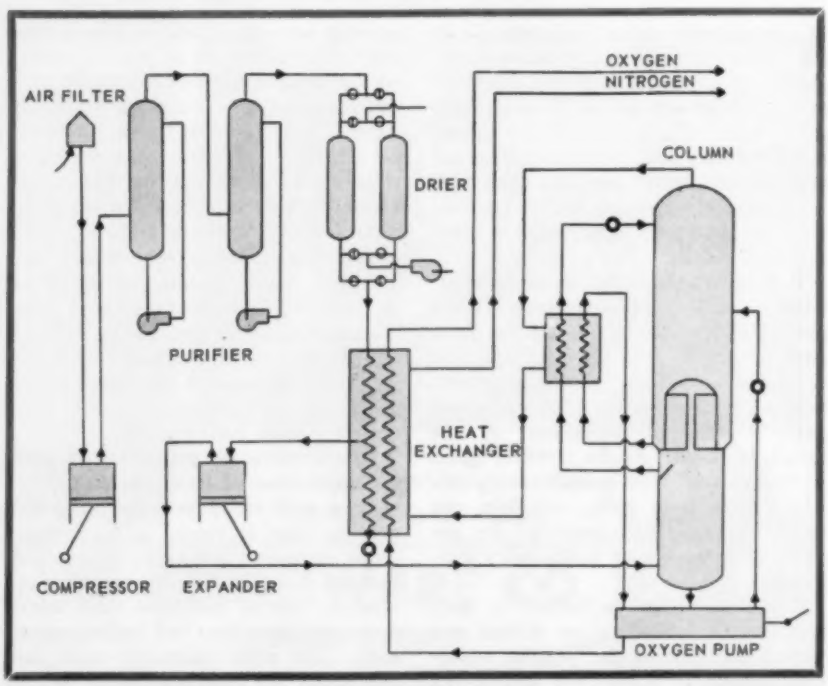


Fig. 2. Simple air separation unit with oxygen pump.

high purity liquid nitrogen reflux. The nitrogen could come from available sources or from an air separation plant. In this cycle the refrigeration and liquefaction of nitrogen is obtained by expansion of nitrogen, followed by heat exchange. It is usually more economical to obtain the refrigeration directly from the air-separation plant, which simplifies the system and decreases the net power going into compression.

The product gas from the unit is controlled to contain hydrogen and nitrogen in the correct ratio for ammonia synthesis. Refrigeration is conserved by the efficient exchange of heat between the product fluids and the feed streams. Here again there are many possible variations of processing, the most economical of which is chosen through intelligent evaluation of all the variables which govern each individual set of conditions.

The combination of unit operations which will comprise the completed cycle for any given set of conditions will be that combination which results in the lowest unit net cost of product over a stated period of time.

The principal elements of cost are the same factors which determine the cost of any process, that is, fixed charges, utilities, raw materials, labor, and maintenance. In many instances the manner in which these elements of cost are evaluated may actually determine the cycle to be employed. Other important, but often difficult, to evaluate factors are simplicity of the system and ease of control and operation. Many purchasers will place a premium on these factors even though their consideration may increase the initial capital investment.

For a low-temperature system most of the power required is for the refrigeration load. For any set of conditions the theoretical amount of refrigeration required will be essentially independent of the actual cycle employed, but the extent to which the theoretical can be realized in practice will vary considerably from one cycle to another. The power required for refrigeration increases greatly as the temperature is decreased. One horsepower will produce about a ton of refrigeration at air-conditioning levels, but at liquid air temperatures up to fifty times this amount may be required. Use of cascade or stepwise systems for introduction of the required refrigeration into the system will reduce the actual power requirement, but the saving could be more than offset by the increased complexity and cost of equipment. Expansion turbines or engines increase the complexity but considerably decrease the net power necessary for the refrigeration load.

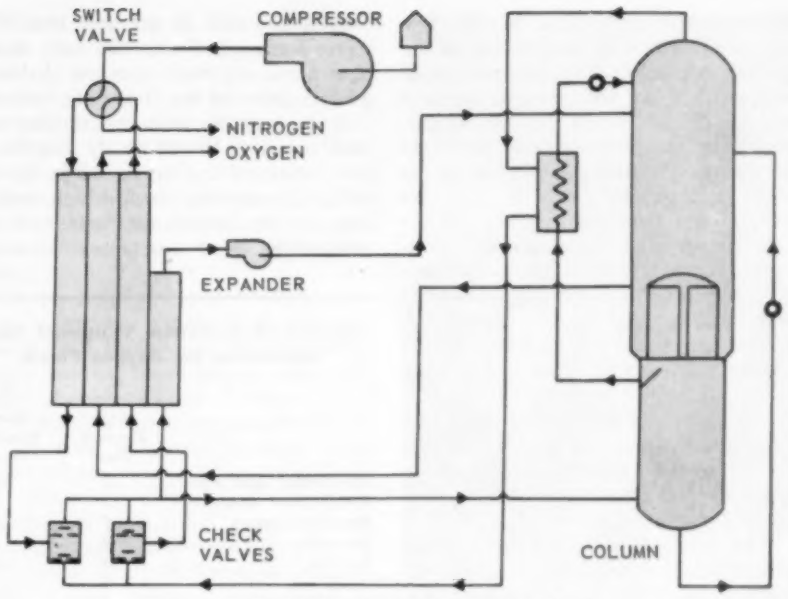


Fig. 3. Simple tonnage air separation unit.

In the case of some small plants it might be more economical to add an extra stage to a standard design of reciprocating compressor and obtain all the refrigeration by Joule-Thomson effect, rather than to compress to a lower pressure and have the cost and

cost estimation

complexity of the expansion engine and its attendant loading device and controls. The economic balance goes in favor of the expansion engine as the size of the plant increases.

The loading device on the expander is usually the means to provide the maximum reliability at the lowest cost. Electric generators are sometimes used, but experience to date indicates that for less than 200 kw. the value of the power recovered will not retire the investment in equipment in a reasonable period of time. High-speed direct-connected centrifugal compressors are used sometimes when the duty of the compressor can be integrated into the process, and the speed and possible load variations can be balanced with the requirements for expander loading. When neither is used, a simple oil brake device is employed, which is relatively low in cost, is easy to control, and dissipates the energy from the expander to cooling water through a simple heat exchanger.

Frequently the products are required at elevated pressures. It is often more economical to design the plant on a

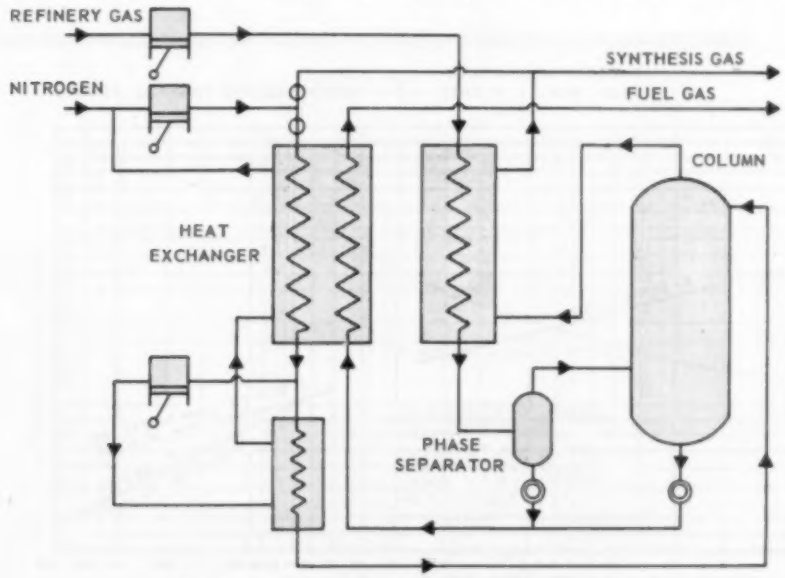


Fig. 4. Ammonia synthesis gas preparation plant.

high-pressure cycle than to use low pressure followed by compression of the gaseous products. The compression of oxygen as a gas, for example, involves many problems which can be circumvented by pumping the cold liquid to the desired pressure and recovering the latent and sensible heats in heat exchange with process streams.

Wherever flow quantities and pressures permit, it is desirable to choose a cycle which will use rotating, instead of reciprocating, machinery since such equipment reduces maintenance and contamination of process fluids with lubricants which must be removed to prevent freezing in the low-temperature area of the process. In general, the economics favors rotating machinery within the areas where such can be commercially procured.

The overlapping ranges must be explored however since there can be situations where either can be employed and the selection of one or the other might significantly affect the cost of the plant. In arriving at this decision, the compressor efficiency and maintenance costs are important considerations which cannot be ignored.

Th most generally used method of removing carbon dioxide and water from the feed air or gas is by scrubbing with weak caustic solution followed by adsorption drying, but cycles which depend on reversing systems and complete freeze-out of these impurities also have their place. Both principles are used widely, although different engineers may tend to emphasize one over the other. Actually, the choice is purely one of economic evaluation. To argue for the elimination of chemicals is a good sales point, but a simple well-designed caustic scrubbing unit is very low in cost. In many small-to-medium size plants, this method is lower in net cost than the freeze-out method. As the unit plant size increases, the economic balance goes in favor of the freeze-out method.

It is desirable that the supplier of such processes be sufficiently flexible in his choice of cycles to adopt either method, depending upon which evaluates to the lowest net unit cost of processing. In some instances the lowest unit net cost system will involve the highest initial capital investment, hence if one were to depend on the availability of money at the time the plant is to be built, this factor might dictate the choice of process rather than engineering considerations. It is therefore important that the engineer understand the significance of the many variables as well as the attitude of his management or client on the method of evaluating each variable.

Table 1.—Approximate Equipment Cost Distribution for Oxygen Plants

	% High-Pressure Plant	% Low-Pressure Plant
Compressor and drive	32	22
Purifier and drier	13	..
Heat exchangers	9	16
Expander	9	12
Column	13	14
Pump	5	..
Controls and instruments	2	12
Piping and valves	12	16
Jacket and insulation	3	6
Miscellaneous costs	2	2

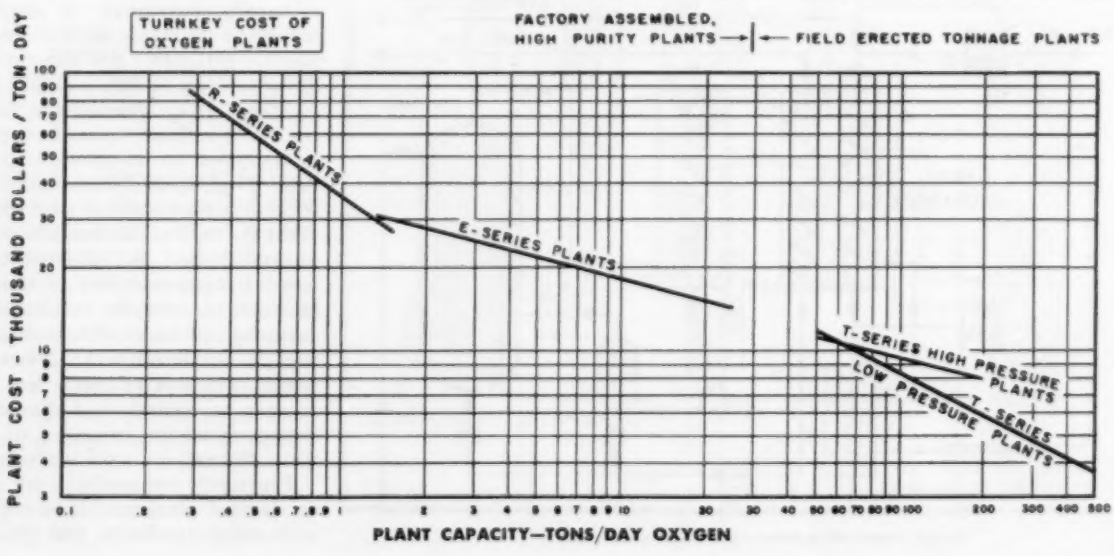
The relative contribution to the cost of the principal individual components of a typical plant of such size that either a low- or high-pressure cycle could be employed at about the same total capital cost is shown in Table 1. The engineer who is faced with choosing between the two alternate schemes obviously has to base his decision on factors other than total initial plant cost.

Figure 5 shows a mean plot of the capital cost per ton daily rated capacity of more than 800 oxygen plants which have been built by Air Products, Incorporated. As one would expect, the unit costs decrease as the plant capacity increases, but in addition, the effect of cycle choice is indicated.

The small plants (R Series) are simple cycles without expansion engines and use high-pressure compression. Low-initial cost and simplicity are stressed. The power requirement per unit of product is high, but is a relatively small element of the total cost of product. The E Series covers the next range up to about 30 tons/day of oxygen capacity. This is a more complicated cycle and uses an expansion engine to reduce the power requirement. Both the R and E Series are standard designs and are completely factory assembled and shipped as packages. This method reduces field engineering and erection cost. The products in each case are delivered at high purity and high pressure for process or cylinder charging without having to compress the gases. Both oxygen and nitrogen are produced. If desired high purity argon may also be recovered.

Oxygen plants of capacity above the range of the standard plants are usually custom engineered (T-Series) and, in general, can be classified into high- or low-pressure cycles. The upper curve is the high pressure and the lower curve is the low pressure. The curve would suggest that the low-pressure would be lower in cost than the high-pressure cycle for most of the size range. This would be true if the products were re-

Fig. 5.


TURNKEY COST OF OXYGEN PLANTS
FACTORY ASSEMBLED, HIGH PURITY PLANTS
FIELD ERECTED TONNAGE PLANTS
PLANT COST - THOUSAND DOLLARS / TON-DAY
R-SERIES PLANTS
E-SERIES PLANTS
T-SERIES HIGH PRESSURE PLANTS
LOW PRESSURE T-SERIES PLANTS
PLANT CAPACITY—TONS/DAY OXYGEN

quired at near atmospheric pressure and there were no extra demands for refrigeration such as withdrawal of a high percentage of product as liquid or furnishing low-temperature refrigeration to another process, such as an ammonia-synthesis-gas purification system, by means of liquid nitrogen scrubbing. When these demands are superimposed on the low-pressure system, the product cost would, in many instances, exceed the cost of producing the same result with a high-pressure system. Most data heretofore published on the cost of tonnage oxygen has ignored these considerations and, therefore, it is believed these data will be a useful addition to that which have previously been released.

Figure 6 is a replot of the same data with the addition of fixed charges, labor, utilities, supplies, and maintenance, so as to show a net cost of product for various plant capacities. The transition from the R Series to the E Series is taken at that point which results in the lowest product cost (Note the resulting curve is reasonably smooth until the transition to the tonnage plant sizes is reached).

The two curves can be used with reasonable accuracy for any applications where oxygen or nitrogen is required. For the tonnage plants the low-pressure curve is used only if the products are required as gases at near atmospheric pressure. For all other conditions the high-pressure curve is used. For low-temperature systems other than air separation, the same type of analysis may be used. Because of the wide variation in the composition of streams to be processed, no such generalized correlations have been made.

For a small commercial plant to produce 90% purity hydrogen from a mixture of 40% hydrogen plus nitrogen, methane, argon, and ammonia, estimates show that the total cost is \$0.52/M cu.ft. of product. Similarly, for a small commercial plant to produce high purity methane from natural gas, the estimated total cost is \$0.54/M cu.ft. methane. Commercial plants referred to here should not be confused with large-scale natural-gas enrichment plants where the processing cost would be substantially less.

For a liquid-nitrogen scrubbing system to produce synthesis gas for ammonia, and the additional refrigeration being supplied from the air-separation plant, the cost will be in the range of \$1.50 to \$3.00/ton of ammonia produced.

The time will come however when more information on these systems can be presented. Because of the wide, possible variations of products being processed, the correlations will probably use power and refrigeration requirements as the common denominator to which the cost of processing a unit of product will be referred.

In the meanwhile, the experience of Air Products and others in the low-temperature processing field is continually increasing and is available to any firm which has a problem to be evaluated.

Acknowledgment

The authors acknowledge the cooperation and assistance of the Air Products organization in developing the material for this paper and, in particular, Alfred Diehl's compilation of the data on which the cost curves are based.

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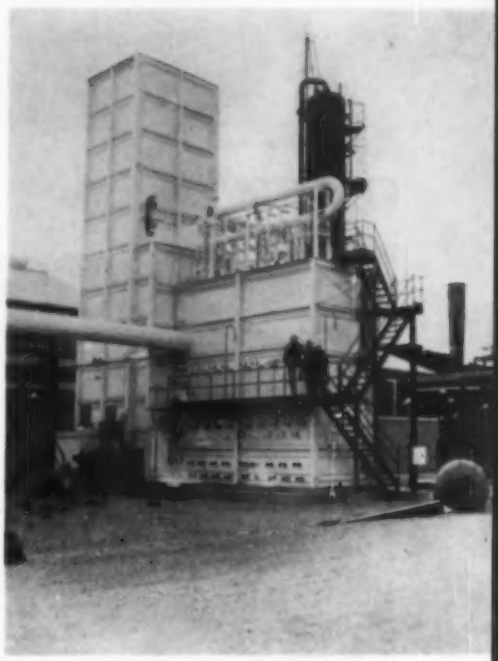
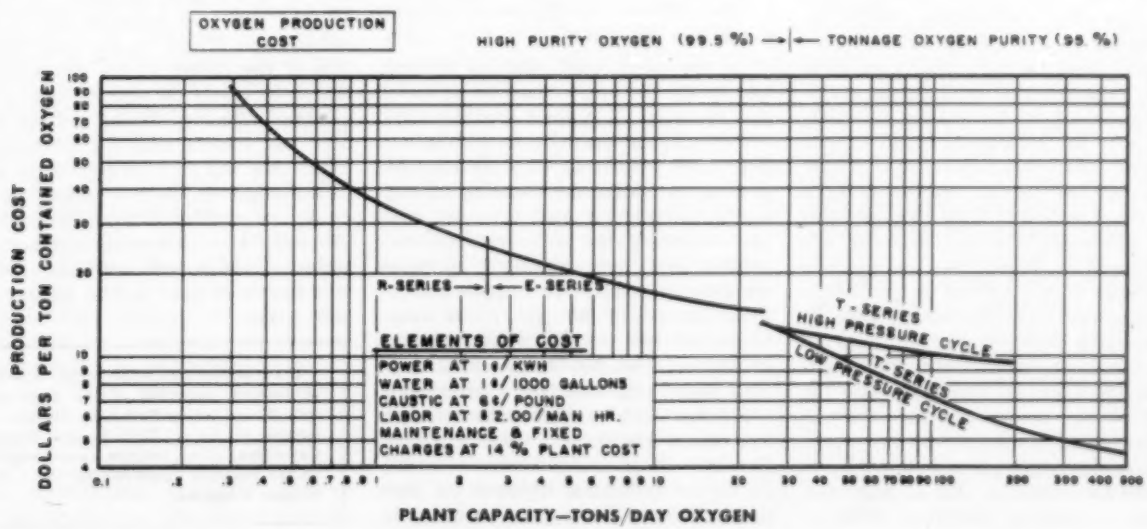


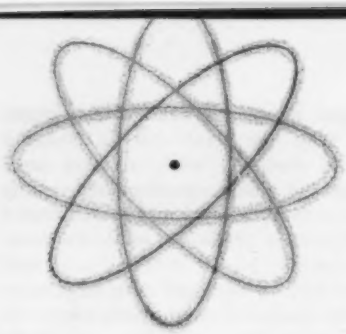
Side view of completely erected air separation plant supplying oxygen and nitrogen for chemical operations at the Vicksburg Works of the Spencer Chemical Company. This unit utilizes the oxygen pump principle delivering this product at elevated pressure. Large pipe leaving cold box (off left center) delivers liquid nitrogen used in low-temperature scrubbing of chemical process stream to yield high purity gases for subsequent catalytic reaction.

Presented at A.I.Ch.E. New York Section meeting October 13, 1954.

cost estimation

Fig. 6.


OXYGEN PRODUCTION COST
HIGH PURITY OXYGEN (99.5 %) → ← TONNAGE OXYGEN PURITY (95 %)
PRODUCTION COST DOLLARS PER TON CONTAINED OXYGEN
R-SERIES → ← E-SERIES
T-SERIES HIGH PRESSURE CYCLE
T-SERIES LOW PRESSURE CYCLE
ELEMENTS OF COST
POWER AT 1¢/KWH
WATER AT 1¢/1000 GALLONS
CAUSTIC AT 6¢/POUND
LABOR AT $2.00/MAN HR.
MAINTENANCE & FIXED CHARGES AT 14 % PLANT COST
PLANT CAPACITY—TONS/DAY OXYGEN



EFFECTS OF nuclear energy ON THE ENGINEER IN INDUSTRY

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Cincinnati, Ohio

I think that those members of the engineering profession who have become a part of the growing nuclear energy industry would agree that engineering as a profession has both gained and broadened by such experience but at the same time the profession has lost something. On the side of gain I would put the increased technical scope of engineering, the increased opportunity for advancement both into top engineering positions and to management positions, and an increased awareness of, and familiarity with, some of the major problems of our National Defense.

Value of Fundamental Training

One of the obvious consequences of the advent of nuclear energy to the engineering profession is the broadened technical area which the engineer is expected to cover. Fortunately, not every engineer who takes part in a nuclear energy activity needs to become a nuclear physicist, but it is evident that some broadening of the scope of the individual is necessary if he is to advance. In a professional sense it seems to me that this is one of the most important effects of nuclear energy developments on engineers, that is, it has brought about an increasing awareness of the value of good fundamental training, evidenced in the caliber of engineers who are sufficiently broad in outlook and sufficiently flexible so that they can think and operate effectively in a number of technical fields. People with such characteristics and training are not commonly found, and in my own experience it has proved both feasible and desirable to create such people by intentionally throwing carefully selected mechanical engineers, chemical engineers, and electrical engineers into the heart of our reactor physics activities for periods of six months to two years. It has also been found possible to achieve the opposite kind of transition by taking a young nuclear physicist or mathematician and introducing him into an effort in which the main concern is the production of hardware and the preliminary drawings and specifications from which this product results. The nuclear engineering curricula, which are springing up in a number of our more advanced technical schools, are proving to be a marked help in achieving the kind of breadth that is needed, but I hope that they will not become overspecialized.

Opportunity for the Engineer

Another striking feature of the position of the engineer in nuclear energy is that his opportunity for advancement is great. One person in six in the nuclear energy industry is primarily technical in background or function. The industry is at present, and probably will be for sometime, dominated by considerations of technical feasibility, and only recently has the more usual dominance of cost considerations come to play an important part. This tends to give the technically trained person an unusually large share in the direction and management of the over-all enterprise.

Atoms and Economics

On the other hand, and on the loss side of the picture, it must be admitted that there are at present engineers and other technical participants in the nuclear energy business who are only beginning to realize the meaning of economic competition and who are only now acquiring the techniques of controlling costs and making choices on economic grounds. The acquisition of dollar sense will take time, and meanwhile we find in the nuclear energy industry a considerable group of technical people who have not yet acquired it.

Another somewhat new characteristic introduced into the engineering profession by nuclear energy is that of mobility of the individual in terms of place and employer. Many have moved from one employer to another as contracts are cancelled or change hands. There is a strong contrast here with the situation which existed 20 years ago, when it was expected that an engineer would make his career with one company. In the nuclear energy industry today it is exceptional to find an individual of stature who has not worked at a number of installations and for a number of different employers. This has had a very broadening effect upon the technical component of the industry, which certainly is beneficial. On the other hand, it has created problems of its own. For example, the individual finds that whereas he may have worked for several different employers and at many different locations, essentially all his work has been done on government contract. This sometimes creates a difference in viewpoint between the industrial employer who is competing with other industrial employers and who regards the government as an important and favored customer, and the individual who in some cases appears to regard the government as his boss and his industrial employer as an administrative convenience.

Nuclear Energy and Aviation

One noticeable characteristic of the nuclear energy industry is its growing similarity to the aircraft industry. In both cases the Federal Government is the primary customer. In both cases the Federal Government has massive technical laboratories and institutions of its own. The similarity between the National Laboratories of the Atomic Energy Commission and the laboratories of the National Advisory Committee for Aeronautics (N.A.C.A.) is too striking to be missed. Both industries are dominated primarily by military considerations. Both industries have a high percentage of technical content and a considerable amount of government ownership of production facilities. It seems obvious that the engineer in nuclear energy who wishes to get some indication of the future of his profession in that field would do well to look at the aviation industry. If the nuclear engineer can expect that his professional experience will parallel that of the aeronautic engineer, he has indeed an exciting and productive future to envision. Certainly he can expect that both his technical and human skills and abilities will be drawn upon to the highest possible extent.

Based on remarks made by Mr. Leverett at General Assembly of the Engineers Joint Council, New York. Mr. Leverett, a member of the A.I.Ch.E. Nuclear Energy Committee, is an Institute representative on the Program Committee for the E.J.C. Nuclear Congress.

Fig. 3. Close-up of extraction and washing units

EXTRACTIVE PRODUCTION OF VITAMIN B_{12} FROM MILORGANITE

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One of the fastest growing fermentation industries in the United States has been the production of vitamin B_{12}. Discovered in 1948, this vitamin, in six years since its discovery, has grown in importance until in 1953 the market requirements were approximately 200 kg., valued at about $10,000,000. As is generally the case with such a rapidly growing business, a number of rather varied production methods have been developed. Some of these processes have been described (*3, 6*), both on a pilot plant and on a commercial scale.

The earliest use of vitamin B_{12} was in the treatment of pernicious anemia and other nutritional deficiencies in humans. However, its use as a feed supplement for nonruminant animals, chickens and hogs in particular, has become far more important. Formerly, these particular feeds contained up to 5% of animal protein, such as meat scraps or fish meal, in addition to their basic constituents, vegetable proteins and carbohydrates. The animal proteins gave a particularly rapid growth response, but added considerably to the cost of the feed. However, the same response can be obtained by the direct addition of vitamin B_{12} to the feed mixture, at a considerable saving. Only a very small quantity of the vitamin is required, of the order of 10 mg. of B_{12} per ton of feed, and it need not be in a pure form.

Recently, in the course of research into possible additional uses for Milorganite, substantial quantities of vitamin B_{12} were discovered to be present in the fertilizer. This vitamin potency was observed to leach out of the fertilizer with water, along with other constituents, and a process for its separation and concentration was developed (*5*). Milorganite is actually dried sludge resulting from the particular sewage treatment procedure known as the activated sludge process. This treatment involves an actual fermentation of the raw sewage and depends upon intense aeration to provide the oxygen necessary for the growth and multiplication of the bacteria which carry out the fermentation. As the fermentation continues, a floc is formed, comprised essentially of the bodies of these bacteria. The completely fermented liquor is allowed to settle and the floc is separated as activated sludge. The sludge is filtered and dried to a granular product, during which operation the cell walls of the bacteria are ruptured, releasing vitamin B_{12} and other water-soluble constituents for future leaching. This paper describes the process which has been developed to extract this B_{12} activity, with special emphasis on the pilot plant tests by which the process was proved feasible for commercial operation.

Pilot Plant Details

In the pilot plant the process began with a thorough prewetting of the Milorganite by concentrated extract solution in an agi-

Stevens and Zinn are also associated with the Vern E. Alden Co., Chicago, and Wolnak with Mid-West Laboratories, Chicago.

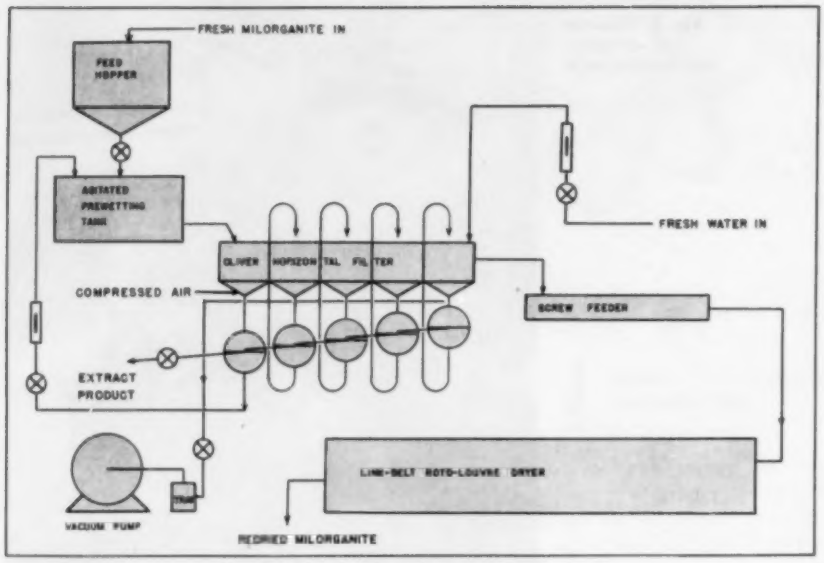

Fig. 1. Schematic flow diagram of pilot plant.

tated tank. From this tank the resultant slurry continuously overflowed to the slowly moving surface of a horizontal filter, where the solid was countercurrently washed with progressively weaker liquors until essentially all the soluble solids had been recovered. The remaining solid, wet with dilute solution, was discharged from the filter and redried, producing a product unchanged in fertilizer value. The concentrated extract liquor was drawn off continuously, evaporated to a thick syrup, and spray dried to produce a vitamin B_{12} concentrate suitable for animal feed enrichment.

Figure 1 shows a schematic flow diagram of the extraction pilot plant, and Figure 2 presents an over-all view of the equipment involved.

The plant consisted essentially of a prewetter tank, a horizontal filter, and a redrier for the treated solid. Fresh Milorganite was added continuously to the prewetter tank from a feed hopper mounted directly above. The feed rate was controlled by an adjustable tapered plug at the bottom of the hopper, the rate through which was checked regularly by a timed sample. A recycle stream of the concentrated extract liquor was also fed into the prewetter tank through a rotameter for rate adjustment. Feed rates of the solution and solid were adjusted to give the desired hold time in the prewetter tank. Too long a soaking extracted undesirable components of the feed and made the solid difficult to redry, and too short a soaking resulted in incomplete extraction of the vitamin B_{12} activity. The slurry was gently agitated during its stay in the prewetter tank, to give good liquid-solid mixing with little particle degradation. Throughout the entire process it was imperative to treat the solid with considerable care, for the success of the over-all development depended in a large part upon whether the redried solid was physically and chemically unchanged from the original Milorganite.

After a suitable stay in the prewetter tank, where the major portion of the extraction took place, the solid, wet with concentrated solution, was discharged onto the surface of the horizontal filter. This unit, described in at least two recent articles (*1, 2*), was the heart of the pilot plant. Here the extracted solid was countercurrently washed to displace the concentrated liquor with which it was wetted. Figure 3 shows a closer view of the prewetter tank and the horizontal filter. The slurry flowed down the inclined trough near the center of the picture. The filter table rotated counterclockwise, carrying the solid under a series of drip boxes from which the various washes were distributed over the surface of the cake, which was approximately 3 to 4 in. thick. Vacuum was applied on the underside of the cake to suck it completely dry after each wash. However, even with the aid of vacuum the cake could be dewatered only to approximately 40 to 45% moisture, on a wet basis, hence several stages of washing were required.

Reference to Figure 4 may give a better idea of the operating cycle of the horizontal rotating filter. Actually, six operations went on at once, each on a particular section of the unit. As can be seen, slurry was fed to the revolving pan where it was evenly distributed by means of an air blow from beneath the filter medium. The solution passed through the filter surface, while the solid moved on to the subsequent washing stages and, after a final wash with pure water, was removed by a screw. Fresh water entered the process at the opposite end of the cycle from the slurry feed. It passed through the cake, displacing the more concentrated solution and was accumulated in a storage tank from which it was recirculated over the same filter section at a rapid rate. This procedure of rapid recirculation through the cake was followed at each washing stage. At the same time a portion of the liquor which had been accumulated in the tank moved to the tank containing the next strongest liquor by simple overflow. Thus, the overall flow of liquid was toward the point of highest concentration where some liquor was drawn off as extract product and the remainder used as recycle to the prewetter tank.

As can be seen from the flow diagram, two product streams left the horizontal filter. One, the concentrated extract solu-

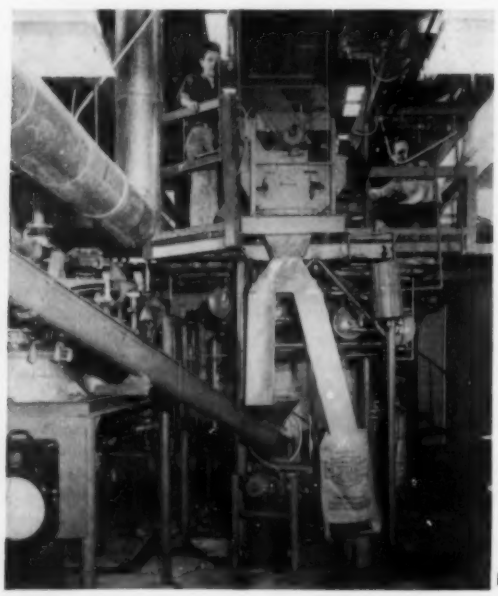

Fig. 2. General view of pilot plant.

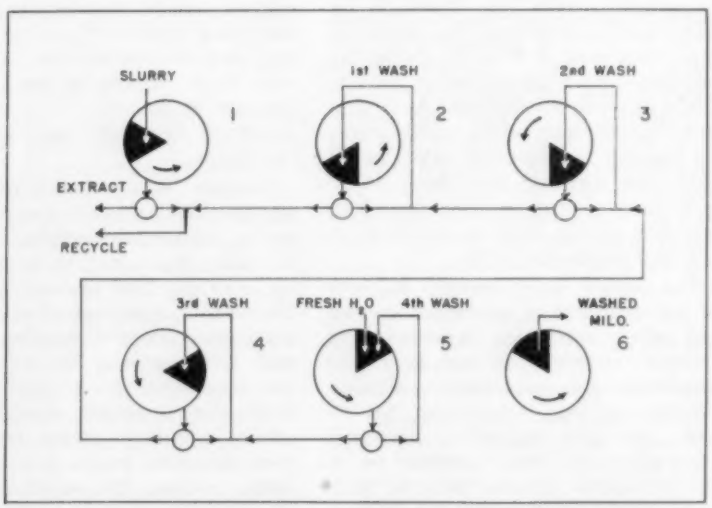

Fig. 4. Operating details of horizontal filter.

Table 1.—Summary of Experimental Data

Run No.	Date	Milorganite Rate lb./hr.	Recycle gal./min.	H_2O rate gal./min.	H_2O in Milorganite %	Solids in final wash %	Yield %	Over-all yield %	Eff. %	Wetting time min.	Wash time min.
1	Dec. 10	124	0.9	0.2	44	2.0	3.9	5.4	71.5	12.9	15.0
2	15	Out of balance									
3	16	235	1.8	0.4	42	2.5	2.9	4.7	62.0	14.6	?
4	17	208	1.8	0.4	43	1.8	3.7	5.0	73.3	15.1	?
5	18	185	1.8	0.6	43	1.8	4.6	5.7	81.0	15.7	?
7	22	189	1.8	0.55	43	1.3	4.2	5.15	81.5	15.6	?
8	23	296	2.5	0.6	42	1.7	3.2	4.4	72.5	10.8	11.8
9	Jan. 7	235	2.5	0.6	43	1.5	4.8	5.9	81.5	23.2	12.5
10	8	263	2.5	0.8	44	1.2	4.3	5.2	83.0	22.4	15.0
12	13	288	2.75	0.7	41	0.9	4.7	5.3	88.5	20.4	?
15	20	250	2.75	0.6	41	1.5	4.6	5.6	82.0	21.2	14.7
16	Jan. 21	305	3.0	0.75	43	1.5	3.9	5.0	78.0	18.9	10.0
17	22	368	3.0	0.9	42	1.2	3.7	4.5	82.0	17.8	10.0
19	26	376	2.75	0.8	42	1.0	3.65	4.35	84.0	18.7	10.2
22	Feb. 5	284	2.5	0.65	43	1.2	4.65	5.5	84.0	21.8	11.9
24	10	359	2.6	0.75	43	1.5	4.4	5.45	80.0	19.7	12.3
25	11	394	2.8	0.9	43	1.2	3.65	4.5	80.5	18.2	9.8
26	12	240	2.1	0.55	43	1.0	5.2	5.9	87.5	26.0	16.3
27	16-19	260	2.5	0.65	43	1.2	4.1	5.0	82.5	22.2	13.2

Runs 1 through 8—small prewetter.
Runs 9 through 27—large prewetter.

tion, contained the vitamin B_{12} which eventually was to be obtained in a form suitable for animal feed; and the other, the washed solid, had to be satisfactorily redried to a condition essentially unchanged from the original Milorganite. The concentrated extract solution (10 to 15% solids, by weight) had to be stored at temperatures below 50° F. in order to prevent additional fermentation and mold growth. However, when the solution was further concentrated to 35 or 40% solids, refrigerated storage was no longer required. Therefore, the extract product solution was evaporated batchwise as rapidly as possible with the use of a long-tube vertical evaporator with natural circulation. A portion of the resulting thick syrup was spray dried to produce a light tan powder, the desired vitamin B_{12} concentrate, suitable for animal feed. Part of this was done on a laboratory spray drier in the pilot plant area, but the major portion was processed in a 14-ft. diam. commercial unit to give a better idea of the properties of the product which would result from full-scale operation. The wet solid was discharged from the filter into an inclined screw conveyor which delivered it to the feed hopper of a rotary drier. In the drier it was carefully handled and dried to give a product physically the same as the original feed except for a slight increase in bulk. Chemically the redried material was a fertilizer equally good as the original Milorganite and could be sold as such.

Experimental Results

After an initial period of breaking in, the pilot plant was operated on a regular schedule for approximately 6 weeks. This schedule involved two shifts of operators so that the plant was potentially in operation 16 hr. a day, 5 days a week. Approximately twenty-five useful experimental runs were made, ranging from 10 to 14 hr. in length, during which time operating conditions were varied and their optimum values determined. As a final test, the unit was operated continuously around the clock for a period of better than 80 hr., with the use of the optimum operating conditions, in order to demonstrate the possibility of continuous operation. During these experiments emphasis was placed on a study of the extraction and washing steps with the subsequent redrying of the Milorganite and the evaporation and spray drying of the B_{12} concentrate carried out on a more or less intermittent basis. Sufficient attention was given to these final steps to prove their feasibility, but no attempt was made to operate them continuously in combination with the initial extraction and washing. A summary of the experimental results from the extraction and washing steps is presented in Table 1 and the recommended optimum operating conditions for these steps are listed in Table 2.

Table 2.—Optimum Operating Conditions

Milorganite feed rate	250 lb./hr.
Recycle rate	2.5 gal./min.
Wetting time (approx.)	22-23 min.
H_2O feed rate	0.65 gal./min.
Table rotation rate	16 min./rev.
Washing time (approx.)	13-14 min.
80-gal. prewettter 4-ft. horizontal filter 4 washes on filter	used

It was found that relatively close control was required on both the fresh Milorganite feed rate and the solution recycle rate to the prewetter tank in order to keep a uniform solid-to-liquid ratio and hence a uniform cake depth on the horizontal filter. Fluctuations in these feed rates resulted in fluctuations in the cake depth which caused channeling of the wash liquors through the areas of lowest resistance and subsequent inefficiency of washing. With a uniform cake depth of approximately 3.5 in. and a vacuum of 1.5-2.0 in. of Hg, washing rates could be increased to as much as 10 gal./min. at each dripbox, with little tendency toward flooding. This rate is equivalent to an average throughput rate of 0.8 cu.ft./(min.)(sq.ft. of filter area), which is excellent for this filter and indicates the degree of porosity of the wet cake resulting from the prewetting by water. Unfortunately, this extreme porosity, though desirable from the standpoint of washing efficiency, also had an undesirable result. The 1% or so of −80 mesh material usually present in fresh Milorganite tended to pass through the filter cake and the 80-mesh screen supporting it, along with the various wash liquors. This silt then deposited itself at different points throughout the system, necessitating periodic clean-outs in order to prevent plugging. Such a clean-out could easily be made between runs during the pilot plant operation; but special provisions for regular clean-outs during operation will have to be provided in the full-scale unit.

In general, it may be said that the amount of B_{12}-active material recovered per unit quantity of Milorganite fed into the process depends upon two major variables. These are the so-called wetting time, or time in the prewetter, and actual washing time, or time on the horizontal filter. The longer the wetting time, the greater the amount of solubles actually put into solution and the longer the washing time, the more efficient the

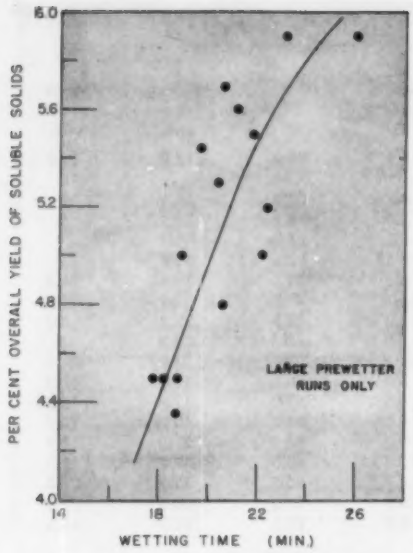

Fig. 5. Over-all yield as a function of wetting time.

washing of the solution from the wet cake and its replacement with water. Previous laboratory experiments had shown that an excellent correlation exists between the amount of all solubles recovered and the amount of actual B_{12}-active material recovered (*4*). The relationship was nearly linear. Hence, determinations of the actual amount of soluble solids obtained in the extract product or still left in the wet cake could be used to represent the recovery and loss of B_{12}-active materials during the process, instead of depending upon the results of the complicated microbiological assay required for direct determination of vitamin B_{12}. The indirect procedure was employed during the pilot plant operation, as can be seen from Table 1; but several checks of final product quality were made by the use of the microbiological assay, with comparable results.

Three representative figures have been calculated from the operating data for each pilot plant run. These are the yield, the over-all yield, and the efficiency, all expressed as percentages. Yield may be defined as the per cent of the total solids charged to the process actually appearing in the extract product. Over-all yield may be defined as the per cent of total solids charged actually dissolved and put into solution. It should be a measure of the extent to which the actual extraction has been carried out. Efficiency may be defined as the per cent of the solubles dissolved actually appearing in the final extract product. It should be a measure of the completeness of washing of the wet cake. These three terms are interrelated, such that only two are independent—for example, the yield is equal to the over-all yield times the efficiency.

As expected, the over-all yield increased with an increase in the wetting time. A plot has been prepared of this relationship and is presented as Figure 5. Apparently there is approximately a linear relationship between over-all yield and wetting time, with some deviation at wetting times above 23 minutes. The correlation is fairly good, and a definite trend is indicated. The efficiency varied from 80 to 88 per cent, with some indication that longer washing times give higher values. Over the range investigated, analysis errors seem to have masked the effect of changes in washing time, and no definite conclusion can be reached as to the effect of this particular variable.

Table 3 lists six analyses of typical feed-grade products, spray dried at various times during the operation of the pilot plant. These indicate a relatively constant quantity of vitamin B_{12}, equal to approximately 18.2 mg./lb., on the average. This is more than sufficient B_{12} for a feed supplement, so that the product should find ready acceptance if the price is right. A market survey is now under way and preliminary sales contacts are being made, with final approval of the construction of a full-sized plant (to handle up to 8 tons per hour of Milorganite) a distinct possibility within the next few months.

In addition to producing a suitable B_{12} concentrate via extraction, evaporation, and spray drying, the process also must recover the unextracted solids and return them to a condition essentially unchanged from the original Milorganite, especially in regard to its fertilizer value. Table 4 summarizes a series of tests which were made to verify that this was so. A nitrogen determination was run both on a sample of fresh Milorganite and on a sample of the same material which had been extracted and redried. The results show that no significant change in the nitrogen content occurred in nine cases checked. To verify completely the fertilizer value of the extracted and redried material, actual field growing tests are now under way at several locations under the auspices of the Milwaukee Sewerage Commission. Their results will determine finally whether the process recovers the unextracted Milorganite unchanged in fertilizer value.

Table 3.—Analyses of Typical Feed-Grade Products

Production Date	B_{12} Content (mg./lb.)
12/31/53	20.8
1/15/54	16.6
1/25/54	19.5
1/29/54	16.5
2/15/54	18.6
2/15/54 (large drier)	17.3
	avg. 18.2 mg./lb.

Table 4.—Nitrogen in Milorganite, Before and After Extraction

Sample Date	% N_2 (dry basis) Before	After
12/21/53	6.22	6.21
12/22/53	6.15	6.08
12/23/53	6.23	6.26
1/ 8/54	6.23	6.22
1/11/54	6.29	6.33
1/12/54	6.32	6.31
1/13/54	6.28	6.28
1/14/54	6.18	6.24
1/15/54	6.30	6.20

Conclusions

Vitamin B_{12} can be successfully extracted by water from Milorganite fertilizer, producing a spray-dried concentrate suitable for animal feed enrichment and leaving a redried solid essentially unchanged in fertilizer value. This extraction process is carried out in an agitated prewetter, with subsequent displacement washing on a horizontal table filter. The pilot plant has proved the operability of the equipment and has indicated a potential yield of approximately 1 mg. of vitamin B_{12}/lb. Milorganite treated as a powdered concentrate containing about 18 mg. of B_{12}/lb. of concentrate. The process should be an improvement costwise over present fermentation processes, because it makes use of the product of a large-scale fermentation process already in operation, namely the activated sludge process of sewage treatment.

Acknowledgment

The financial support and technical assistance of the Vern E. Alden Company, Engineers, who sponsored this work, are hereby gratefully acknowledged.

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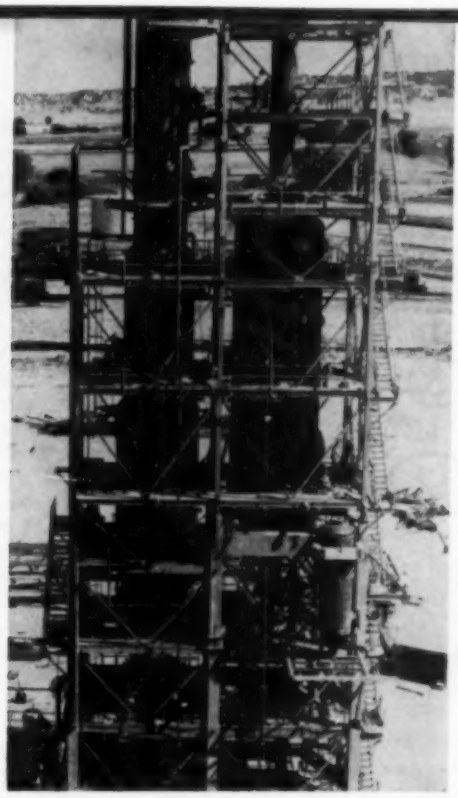

Fig. 1. Billings, Montana, Fluid coker during construction.

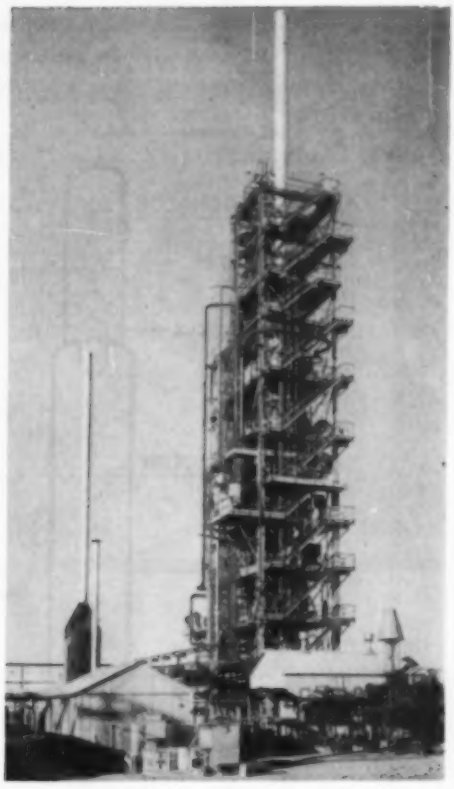

Fig. 1A. Billings, Montana, Fluid coker.

fluid coking and fluid coke

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In recent years the market for heavy fuel oil has not expanded so rapidly as consumption of gasoline and heating oil. In addition, there has been a trend toward processing heavier crudes. These factors have created a real need for a refining process to upgrade heavy residual oils to lighter products. Although vacuum distillation is widely used, it has not given sufficient reduction in heavy fuel. Delayed coking can be used, but it is not a continuous process, and has not been successfully applied to all types of residua.

Fluid coking now makes it practical to reduce or eliminate the production of residuum from crude, regardless of its quality. Development of the process has been described by Voorhees and Martin (*1*). Fluid coking is especially attractive in that it provides a maximum of gas oil suitable for catalytic cracking from materials which might otherwise give no distillate products. An appreciable amount of naphtha is also formed, and the coke produced, while kept at minimum yield, is a new and unusual material.

Since Fluid coke is distinctly different from the petroleum coke now known to the industry, there has developed considerable interest in its properties, handling techniques, and potential markets. Plants now under way can produce Fluid coke at the rate of 200,000 tons/yr. or more. Even this volume is not large compared to current consumption of coke. For example, some 70,000,000 tons/yr. of metallurgical coke are used in the United States alone.

First commercial production started late in 1954 at the plant of the Carter Oil Company at Billings, Montana. Figure 1 is a photograph of the Billings unit under construction. In this incomplete state the burner vessel, and the reactor vessel with the scrubber on top of it are easily identified. Figure 1A shows Billings fluid coker.

Description of Process

This coking unit consists of a reactor, heater, and primary fractionator as shown in the flowsheet of Figure 2. The system is similar to a fluid catalytic cracking unit but operates with coarser solids. The hot residuum feed is sprayed through nozzles into a bed of finely divided fluidized coke in the reactor. The latter operates in the range of 900-1,050° F., and a pressure somewhat above atmospheric. The solids are fluidized by steam added at the bottom of the reactor, as well as by the cracked products generated in the bed. The liquid feed distributes itself over the surface of the particles and is decarbonized and vaporized. Vapors leaving the reactor pass through a cyclone to separate entrained coke particles and then enter a scrubber and fractionator tower.

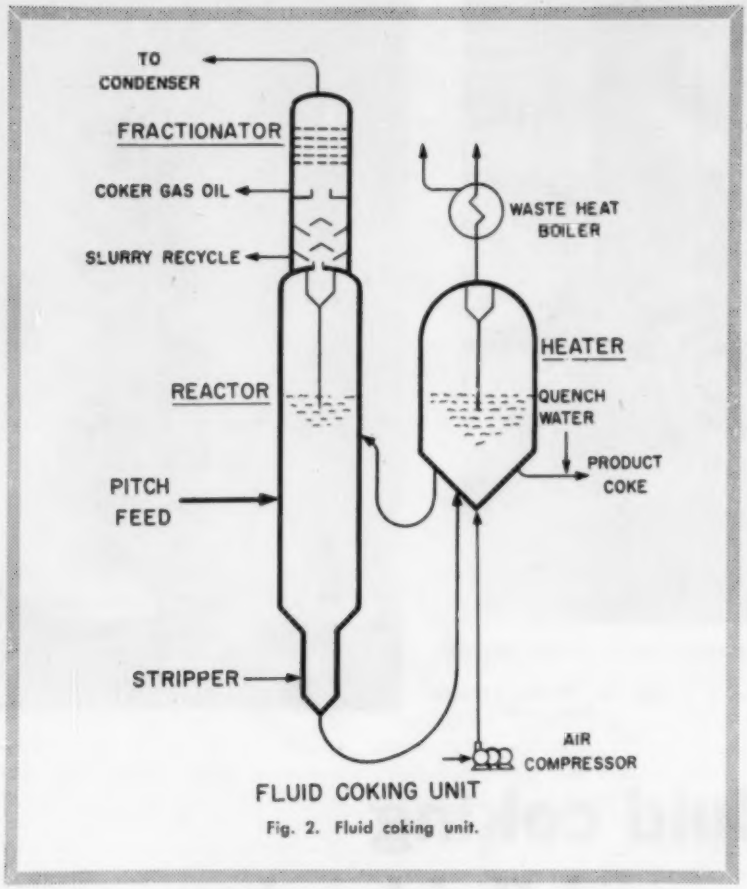

Fig. 2. Fluid coking unit.

In the scrubber the remaining coke particles are removed from the product vapors and recycled to the reactor as a slurry in the heaviest portion of the product. It has been found that trouble with coke deposits in the overhead system can be avoided by proper design and choice of operating conditions.

In the reactor the decarbonization reaction deposits a layer of coke on the particles in the bed. This deposit comprises components of the feed which have a high tendency to form coke, whereby they are removed from the distillate products. In addition, all but a minor part of the metallic contaminants and ash in the feed are retained in the coke. This is important since the ash content of pitches is very high compared to normal, distillate petroleum products.

Part of the product coke is burned in a fluidized bed heater to furnish the heat required in the process. Air is added to the bed, which is at a temperature of 1,100-1,200° F., and combustion proceeds primarily to carbon dioxide so that fuel efficiency is high. If desired, an extraneous fuel such as oil may be burned in the heater preferentially to the product coke. To supply process heat, about 5-7% on feed of coke, or its equivalent in extraneous fuel, must be burned. The hot coke is circulated to the reactor to maintain a proper reactor temperature, and coke is returned to the heater by way of a stripper wherein hydrocarbon vapors are displaced by steam to prevent their being carried over to the heater. Coke is circulated with the use of standpipes and risers as is common in fluid-solids operations. However, the arrangements used in catalytic cracking have been modified somewhat to be more suitable for handling the coarser solids.

The particles tend to grow in size in the reactor as a result of the coke deposition. To maintain desired particle size in the system, large particles must be removed, and replaced by small "seeds." A simple grinding system in the reactor furnishes the necessary seeds. Product coke can be withdrawn from either the burner or reactor. It flows to an elutriator which returns finer particles to the system and provides flexibility as regards size of product coke withdrawn. Product coke is quenched to a safe-handling temperature by direct injection of water in the elutriator.

PRODUCT YIELD AND QUALITY

Typical yields from Fluid coking are shown in Table 1. These have been discussed in somewhat greater detail by Martin, Barr, and Krebs (*2*). The major product is gas oil boiling in the range of 430° to about 1,015° F. cut points. This may amount to 50-60% on residuum feed and is a desirable feedstock for catalytic cracking. The catalytic cracking carbon yield will be higher than for a comparable virgin gas oil, and the optimum catalytic conversion will be somewhat lower. Cracking tests indicate that the catalytic cracking carbon yield from the 430/1,015° F. coker gas oil is about twice that from virgin gas oil from the same crude at a given conversion.

Coker gas oil need not necessarily be used as catalytic cracking feed. If preferred, a cut of the appropriate boiling range may be sold directly as heating oil, etc., although some treating would probably be required.

An appreciable amount of naphtha is formed in Fluid coking and represents a major contribution in product value. Although the octane number is higher than from delayed coking, it is still low by present-day gasoline standards. Coker naphtha generally will require treating and it can be finished by hydroforming, hydrofinishing, clay treating, etc.

The light ends from coking contain large amounts of olefins which can be used for polymerization. For example, there will be about 40% unsaturates in the C_2 hydrocarbons, 60% in the C_3, and 75% in the C_4 hydrocarbons.

FLEXIBILITY OF PROCESS

Fluid coking can easily handle a wide variety of heavy feeds, including stocks of high Conradson carbon. There appears to be no limit on heaviness of feed, so long as it can be pumped. Lighter components can be included in the coker feed with little or no effect on coking of heavy components. The practical range of feedstocks and coking temperatures has been extended greatly by using the fluid solids technique since the process does not depend on a feed preheat furnace. Also, it becomes possible to cut to a high endpoint on the coker gas oil. In this way the heavy coker gas oil can be cracked catalytically instead of being recycled to the coker.

There is some degree of flexibility in conversion.* Although all products other than coke are distillate in the sense that they must come out of the coking zone as vapor, the amount of material higher boiling than desired for catalytic cracking feedstock can be controlled to some extent by varying conditions. For ultimate yield of high-value distillate products this high-boiling material is recycled to extinction. In some cases,

* Defined as 100 - vol.% liquid product boiling above the coker gas oil endpoint of 1015° F.

depending on product outlet and coker feed quality, it may be desirable to withdraw some of this stream, in order to prevent the total feed from becoming too refractory. Operating conditions and extent of recycle also may be used to vary the naphtha yield, if desired.

It will normally be desirable to use a high endpoint on the coker gas oil to increase the yield of valuable catalytic cracking feedstock. This will be limited by the quality of the heavy ends, with respect to the tendency to form carbon during catalytic cracking and to the presence of contaminants. The exact cut point will depend upon the particular coker feed, etc., but the 1,015° F. used in Table 1 has generally proved satisfactory.

Fluid coking allows partial or complete elimination of liquid fuel in the refinery. In this respect it is more flexible than deasphalting. Fluid cokers can also be built in large sizes similar to Fluid cracking units, so that it is unnecessary to go to multiple units to provide a high capacity.

Coke yield also varies somewhat with ultimate conversion as affected by recycle. Net coke make can be controlled within limits by burning extraneous fuel in the heater. Product coke size can be varied over a considerable range if desired, and may be withdrawn from either the burner or reactor side.

Table 1.—Fluid Coking of Residua

Estimated yields recycling fractionator bottoms to extinction

Crude Source of Vacuum Pitch Fed	So. Louisiana Mixture	Hawkins
Feed Inspections		
Gravity, ° A.P.I.	13.2	4.2
Conradson carbon, wt. %	14	24.5
Pour, ° F.	120+	120+
S, wt. %	0.9	4.3
C, wt. %	87.3	85.1
H, wt. %	11.5	10.1
viscosity, SSF @ 275° F.	60	400
Ultimate Yields on Coker Feed		
C_5—, wt. %	8	9.5
C_5/430° F. v.t. naphtha, vol. %	24	23
430/1,015° F. v.t. gas oil, vol. %	61	52
coke, wt. % (gross)	16	27.5
Product Quality		
naphtha res. oct. no., clear	77	77
sulfur, wt. %	0.1	0.7
gas oil gravity, ° A.P.I.	21	17
sulfur, wt. %	0.6	3.7

ECONOMICS

In Table 2 some typical Fluid coking economics are presented. These are based on feeding vacuum pitches from South Louisiana and from Hawkins crudes, representing paraffinic low-sulfur and asphaltic high-sulfur feedstocks respectively.

Investment and operating costs for a 10,000 bbl./stream day coker are shown. A larger plant would show increased savings on a unit cost basis. There appears to be no limitation in allowable size of the single unit within several fold this capacity. It will be observed that both high- and low-sulfur feeds show attractive returns for installation of coking.

The figures used in these economics are felt to be realistic. Investments are based on cost estimates from a number of contractors for construction conditions and standards normal in the industry. In evaluating the feed and products, provision for auxiliary processing facilities, such as treating, etc., was made, and costs of these operations were deducted. These deductions include operating cost plus 10% return after income tax on investment including general facilities associated with the auxiliary steps. The pitch feed itself was in each case evaluated as a component in No. 6 fuel oil. The figures are for Gulf Coast conditions, but adjustment to economic conditions in other parts of the country is easily made.

Table 2.—Estimated Economics of Fluid Coking on Gulf Coast

10,000 bbl./stream day of vacuum pitch feed

Crude source	South Louisiana	Hawkins
Coker investment, battery limits	$2,150,000	$2,300,000
Value of products, $/bbl. pitch *		
C_5 and lighter	$0.07	$0.09
C_5 to 430° F.	0.77	0.74
430° to 1,015° F.	1.65	1.04
Coke	0.14	0.25
	$2.63	$2.12
Feed value, $/bbl.	$1.25	$0.75
Coker operating cost, $/bbl.	0.24	0.24
	$1.49	$0.99
Profit, $/bbl.	$1.14	$1.13
Return before taxes** %/yr.	175	165
$5/ton added coke value adds, %/yr.	21	36

* Product values used:

Fuel gas	$0.90/bbl. F.O.E.
C_5—430° F.	$3.20/bbl. F.O.E.
430—1015° F.	$2.70/bbl. So.La.
	$2.00/bbl. Hawkins
Coke	$5.00/ton.

** Excluding royalty.

A few comments can be made on the effect of sulfur and of feed cost and product value. The amount of desulfurization accomplished in Fluid coking is no more than is normal in any cracking process. Some concentration of sulfur in the gas does occur. In general, however, high-sulfur pitch will produce high-sulfur gas oil and catalytic feedstock, and relatively high-sulfur naphtha. The gas oil may be desulfurized before catalytic cracking although under many conditions it may be advantageous to desulfurize the catalytic products instead. Hydrogenation-type desulfurization operations are suitable for coker naphtha, coker gas oil, or products from catalytic cracking of the coker gas oil. Whereas the hydrodesulfurized naphthas show some decrease in clear re-

Figs. 3-6 Show coke as withdrawn and forms in which it can be used.

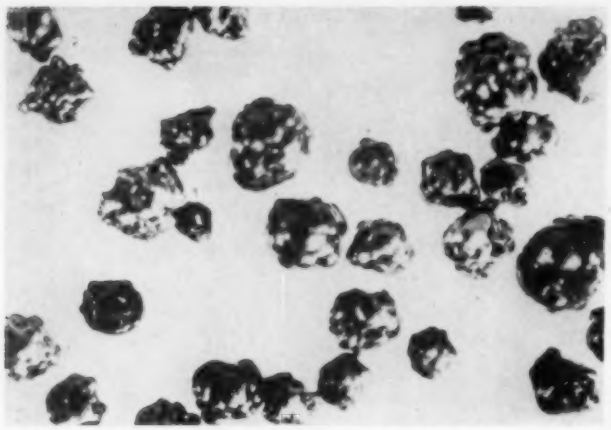

Fig. 3. Rounded particles of Fluid coke.

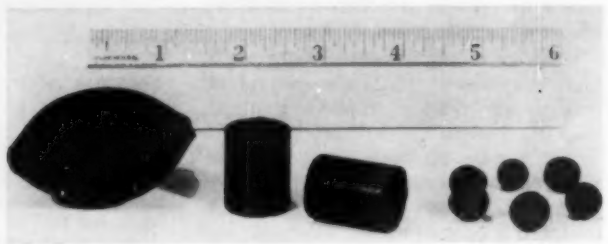

Fig. 4. Pellets and briquettes made from Fluid coke.

search octane numbers, the decrease in leaded octane number is small, and under some conditions the hydrodesulfurization can actually improve the leaded antiknock quality.

Actually the difference between high-sulfur and low-sulfur feedstocks may not be so great as would at first appear. If fuel oil is being produced to a sulfur-limiting specification, the lower value of the high-sulfur feed as a fuel oil component may offset the lower value of its coking products. Even if fuel oil sulfur is not limiting, high-sulfur pitches are often associated with lower fuel oil blending quality from the viewpoint of viscosity, stack solids, and other fuel specifications. These considerations tend to equalize the net profits from feedstocks of widely different quality. In Table 2 the gross profit per barrel of pitch tends to run about $1.15. Based on the on-site investment for the coker, this provides a return of about 170%/yr. or 75-80% after allowance for 55% income tax.

COKE QUALITY AND VALUE

The economics set out in Table 2 credit the net coke make from the unit at Gulf Coast fuel value of $5/ton, or somewhat more than 15¢/million B.t.u. Complete elimination of the coke credit has only a minor effect on the over-all profit from Fluid coking. On the other hand, opportunity for additional profit by getting improved realization on the coke is significant. Thus, on the East Coast the fuel value of the coke would be in the neighborhood of $10/ton instead of $5. For specialty purposes coke of the proper quality brings prices up to $25/ton, and higher. On this account a closer look at the quality of coke produced in Fluid coking and at its uses is of interest. This, together with some discussion of techniques for handling Fluid coke, will now be considered. Figures 3 through 6 show the coke as withdrawn and forms in which it can be used.

Some of the pertinent inspections by means of which coke quality may be judged are shown in Table 3. Fluid coke is a new and interesting product. It consists of rounded particles of a relatively narrow size range (Figure 3). It is hard and resistant to attrition although it can be ground satisfactorily by a number of techniques. It pours and flows easily and is clean compared to most carbonaceous materials.

Fluid coke has about 1½ to 2% H as produced, and a volatile matter content in the neighborhood of 1% at 1,100° F., and 5% at 950° C., the temperature for determining volatile matter more commonly used in the solid fuels industry. Besides hydrogen, the coke contains sulfur and ash, but the carbon content is generally about 90%.

Fluid coke has a high ignition temperature and does not give problems relating to explosion or firing in storage under normal atmospheric conditions. However, it is burned without difficulty in the fluidized bed heater vessel of the coking unit at temperatures in the neighborhood of 1,100-1,200° F.

The sulfur and ash in Fluid coke are, of course, a reflection of the feedstock used. There is no desulfurization effect in the coke. In fact the examples shown indicate that the sulfur in the feed is concentrated somewhat in the coke. However, it is hoped that attractive means for desulfurization can be developed. Long-range work on this problem is under way in the laboratories of the Esso Research and Engineering Company.

Most of the ash remains in the coke. Since the coke make from Fluid coking is low, the ash content will be somewhat greater in Fluid coke than in other types of petroleum coke. However, in the over-all economics of the process, it is more important to keep the ash out of the high-value liquid products. For some uses, however, ash composition of the coke must be carefully watched. Even for burning, although the ash is much lower than in coal or metallurgical coke, the ash composition may on occasion be a factor to keep in mind.

Size of coke produced by the Fluid coking process will be in the range of about 20-100 mesh. The material withdrawn can be increased in size by use of elutriation techniques and the like. However, it must be remembered that the smaller the particles removed from the system the greater the grinding load for providing seed coke will be.

TRANSPORT

A number of conventional solids-handling systems are available which can be used for transporting coke to storage, for recharging the unit at start-up, and for loading coke into trucks, railroad cars, barges, etc. Several such systems have been tested with Fluid coke. Also, circulation of coke through standpipes and risers has been studied in glass equipment, the 100 bbl./day pilot plant, and a still larger special circulation test setup. Fluid coke has been handled as successfully as fluid cracking catalyst by proper choice of conditons.

Selection of the transport system will depend upon the distance to be covered, the vertical life (if any) and whether the handling is continuous as on the discharge from the coker, or intermittent as for filling trucks, railroad cars, or barges. The various product coke transport techniques can best be classified according to the horizontal distance covered. For distances up to a few thousand feet the following are suitable:

Fig. 5. Metallurgical coke with Fluid coke as a low-volatile component of the charge.

1. Pneumatic transport.
2. Fuller-Huron Airslide.
3. Belt conveyors.

In the pneumatic system, which is perhaps the simplest, the coke is blown through a pipe line at relatively high velocity. Air or other carrying gas must be supplied at adequate rate and pressure. No special equipment is needed, although the solids must be recovered at the discharge end by means of a cyclone, settler, bag filter, or the like. The number of bends in the line should be minimized, but where required long radius bends will assure smooth flow and avoid erosion.

Pneumatic transport of Fluid coke has been successfully demonstrated in tests conducted jointly with Robinson Air-Activated Conveyor Systems. Tests were made at constant conditions characteristic of continuous operation. The system was also operated in a batch manner with the use of the lock hopper as a blow case. This equipment has been employed commercially for transport of cracking catalyst, cement, and various other materials.

The Fuller-Huron Airslide, made by the Fuller Company, was used in a successful series of demonstration runs. The Airslide has been employed commercially on a great many different materials. It consists of a trough, the bottom of which is made of porous material to permit aerating the solids with air or other gas. With this aeration the fluidized solids flow downhill similar to a stream of water.

The pneumatic system is somewhat simpler than the Airslide but will normally have a higher power consumption for air compression. With an Airslide, aeration air is needed at a constant pressure, and the amount is proportional to its length. On a pneumatic system the pressure drop increases with line length although it can be reduced by using more air and a lower solids loading. Solids must be available at sufficient pressure to introduce them into the high-pressure end of the transport line. This may require pressuring the coke by means of a fluid solids standpipe, or a lock hopper, etc. Little or no pressure head is needed on the solids to add them to an Airslide.

Product coke can be transported also on conventional belt conveyors. These will generally have a lower power requirement than the Airslide or pneumatic type. Characteristics of this kind of system are well known and several manufacturers offer suitable equipment. Belt conveyors can be used for raising the coke also, up to an angle of 20° with the horizontal.

Choice among the various systems is largely a matter of economics, which will vary for each application. It will depend on such things as distance to be covered, relative elevations, number of changes in direction required because of roads and obstructions, relative importance of investment vs. operating cost, etc.

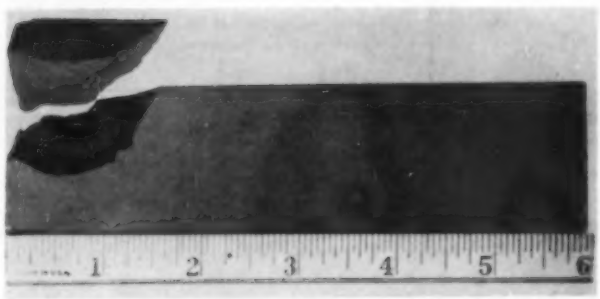

Fig. 6. Small test carbon electrodes for aluminum manufacture.

Table 3.—Typical Fluid Coke Inspections

Crude source of vacuum pitch fed	So. Louisiana Mixture	Hawkins
Volatile matter, wt. %		
At 1,100° F.	0.6	0.9
At 950° C. (1,742° F.)	5.0	5.0
Carbon, wt. %	92.5	88.3
Hydrogen, wt. %	1.6	1.9
Sulfur, wt. %	1.4	7.0
Ash, wt. %	0.78	0.33
Ash components, wt. % metal in coke		
Nickel	0.021	0.010
Vanadium	0.003	0.015
Iron	0.055	0.007
Particle density, g./cc.	1.5-1.6	
Bulk density, lb./CF	55-65	
Approximate heat of combustion, B.t.u./lb.	14,000	

Ash and ash components estimated for 100% conversion recycle operation. All other data from once-through operation of the 100 bbl./day Fluid coking pilot plant. Sulfur will actually be somewhat lower in recycle operation.

Where the coke must be lifted vertically, this can be done using the fluid-solids technique. The system consists of a vertical riser through which the coke flows upward at low density. Sufficient riser gas is added to give the desired low density. The pressure head needed to introduce the solids into the riser can be developed by a standpipe or by simply extending the riser down into a bed of the Fluid coke. Conventional bucket elevators can be used instead, and many different types are available.

Fluid coke can be transported in bulk over longer distances by truck, rail, barge, or ocean shipping. Some protective covering will be needed to avoid excessive loss of coke. A tarpaulin will be satisfactory, or covered trucks or rail cars such as have been used for cracking catalyst can be employed. There are available rail cars equipped with Airslides at the bottom to facilitate unloading.

STORAGE

Two coke storage requirements must be considered: (1) the provision for charging coke to the unit during starting up and (2) the larger capacity normally needed to store coke between shipments. In most cases the two storage systems can be combined.

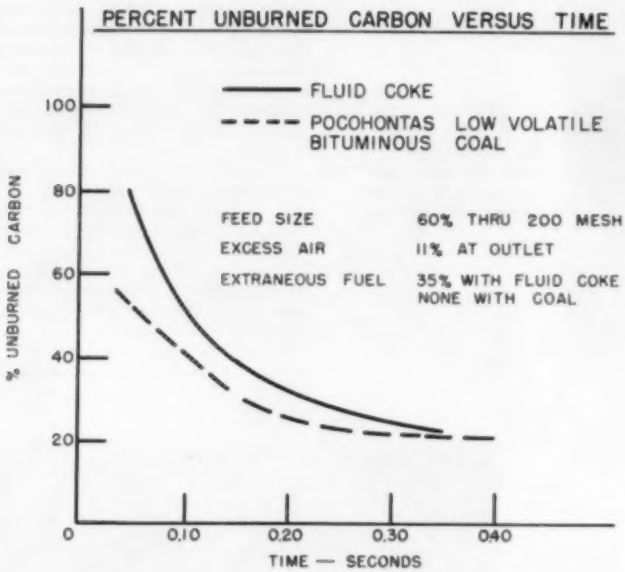

Fig. 7. Experimental furnace test burning Fluid coke.

The product coke is of small size and is free flowing, so that in open storage the pile may have to be protected to prevent high losses from the action of wind and rain. Where feasible, a tarpaulin or similar covering can be used. As an alternate, oil or tar can be sprayed over the surface of the pile. This simple technique has been used successfully on storage of coal fines. Tests with it on Fluid coke are under way at present. Such a protective coating could also be used on trucks, railroad cars, barges, etc.

Where circumstances require greater protection, coke can be stored in conventional types of tanks, silos, bins, etc. Covered storage has the advantage that the coke is kept dry and this insures its easy handling by fluidized-solids techniques.

A steel tank of the type employed for oil storage can be used for Fluid coke; it is simple and relatively inexpensive. Coke additions and withdrawals are made at the center of the tank to avoid unbalanced stresses which might result if the coke piled unevenly against the tank wall. Aeration manifolds are provided in the bottom of the tank to allow emptying it more completely and to avoid dead storage. Airslides can be used for this, or pipe distributors can be designed for the service. As an alternate, the bottom of the tank can be sloped at about 35° toward the outlet, in which case the aeration can be omitted. The large storage tank carrying coke away from the unit provides an ideal settling chamber for the discharge of the pneumatic transport system.

Conventional pneumatic or mechanical loading systems are suitable for moving coke from the storage tank into railroad cars, etc., for shipment to customers. The loading system will operate at a relatively high rate for a short period of time, particularly in the case of water transport. Cost for this equipment will be minimized by locating the main storage as close as practical to the ultimate loading point.

For recharging the unit at start-up, coke can be returned through the same transport line that carries coke from the unit. The coke from the storage tank can be pressured for return through the transport line by means of a Fluid standpipe or lock hopper arrangement. The Robinson-type automatic lock hopper is well suited for this service.

FLUID COKE AS FUEL

Although Esso Research and Engineering Company is actively pursuing the development of high-value outlets for Fluid coke, it is clear that the base load for coke disposal is most likely to be its burning in boiler furnaces or the like. Accordingly, a program of testing is being carried out. Data are available on the burning characteristics of Fluid coke which are applicable to its firing as in conventional boiler pulverized fuel furnaces. Some preliminary information is also available on its burning in stoker-fed furnaces. There are, of course, data available on burning coke in fluidized solids beds—of the type which is actually used to supply heat for the coker itself.

In the burning of Fluid coke, its relatively poor ignition characteristics must be kept in mind. Although this property is valuable in storage and handling of the coke, it does mean that special care must be taken in its combustion as with other low-volatile fuels. Ignition and burning rate problems can be cared for by a combined use of auxiliary fuel and Fluid coke ground to the proper size.

Experimental Furnace Tests

Preliminary indications are that Fluid coke is about as easy to burn as low-volatile bituminous coal.

In experimental furnace tests conducted at Battelle Memorial Institute, the unburned carbon remaining with Fluid coke was essentially the same as with low-volatile bituminous coal of the same fineness burned under the same conditions. Since these coals are normally burned satisfactorily in conventional boiler furnaces to 1-2% or less unburned carbon, no major problem is expected in the combustion of Fluid coke in furnaces of conventional design. The experimental tests are only indicative since they do not fully duplicate commercial boiler furnace conditions, for instance, with time-temperature relationships.

In Figure 7, typical generalized results of tests in the experimental furnace are given. Here reduction of unburned carbon with burning time firing Fluid coke and a low-volatile bituminous coal (Pocahontas) is shown. Although the curves differ in shape, the unburned carbon from coke is as low as from coal after 0.4 second burning time. The unburned carbon levels are high because of the short combustion time used compared to full-scale boiler furnaces. This facilitates the distinguishing between fuels of different burning characteristics. Large tests are planned to confirm the favorable indications from the experimental furnace.

These tests were made using an auxiliary fuel with the coke—in this case gas. High-volatile coal has also been used satisfactorily and oil could be too. In a test made with no auxiliary fuel the amount of unburned carbon was not appreciably higher. However, the function of the auxiliary fuel is to bring the coke up to its ignition temperature and to help to maintain a stable flame. Auxiliary fuel of the order of 15-30% on total fuel is generally sufficient. In fact, owing to the tendency for the auxiliary fuel to burn first and hence to rob the coke of part of the original oxygen supply, too high a concentration of auxiliary fuel is probably not desired. It does appear, however, that the range of fuel mixtures in which Fluid coke can be burned is wide.

The tests indicated the expected trends with excess air. No significant differences between Fluid coke and low-volatile bituminous coal were observed. The effect of fineness of the coke was also studied. Grinding to 80-90% through 200-mesh improved burning rate moderately. The effect appeared to be about the same as with the coal.

In firing Fluid coke the unburned carbon represents the major part of the solids withdrawn from the furnace. With coals, however, an additional 10%, or thereabouts, of ash also goes out of the system. For comparable total solids loss in combustion Fluid coke could afford to have up to say 10% unburned carbon. Since the heating value of Fluid coke will be in the neighborhood of 14,000 B.t.u./lb., the net heat available even with higher unburned carbon compares favorably with run of the mine coal, such as is normally fed to large-scale boiler-furnace installations.

GRINDING

The cost of grinding Fluid coke is somewhat greater than that of bituminous coals so that there is greater incentive for reducing the amount of

grinding required. On this account it may very well be desirable to allow for a higher unburned carbon and take the advantage allowed by this in terms of reducing the amount of grinding.

Fluid coke can be satisfactorily ground with the use of either an impact-type mechanical mill or a jet attrition-type mill. The mechanical impact appears to be supplied best in a conventional ball mill. In such equipment capacity of a given mill for coke is 45-50% of that for an average bituminous coal of about 55 Hardgrove grindability index. Power requirement is in proportion, so that grinding cost may be said to run two to two and one-half times that for a conventional boiler-furnace bituminous coal. With ball mill, if conventional coal grinding costs are taken at 25¢/ton, the costs for grinding Fluid coke would be of the order of 60¢/ton.

As indicated previously, it seems likely that grinding Fluid coke to the same extent as is normally practiced with bituminous coal, *i.e.*, 80-90% through 200-mesh, would give unburned carbons from the coke in the neighborhood of 1-2%. Where Fluid coke is burned in a furnace equipped with efficient fly ash collection equipment, unburned coke can be recovered and returned to the combustion zone. This permits operating with a relatively high per cent unburned carbon leaving the furnace, while the fuel efficiency corresponds to a much lower unburned carbon. Thus, a coarser coke size may be fired with a corresponding saving in grinding cost. In fact, in some cases grinding may not be required.

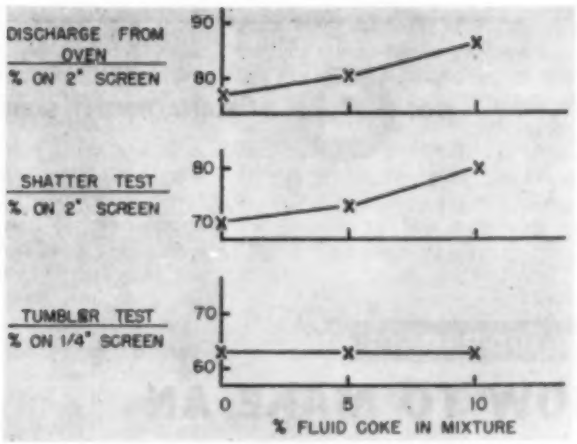

Fig. 8. Properties of metallurgical coke with Fluid coke as component of the charge.

OTHER USES

Although the development of a market for Fluid coke as boiler furnace fuel has been undertaken to supply the base load, specialty uses are also being explored and developed. Some of the more interesting possibilities in this field include the use of Fluid coke in carbon electrodes for the aluminum industry, and in the manufacture of calcium carbide, phosphorus, and carbon disulfide.

It is also possible that Fluid coke might well be developed for use in metallurgical industries. In this, as in some of the others, the development of pelletizing or briquetting techniques–some way of "making big ones out of little ones"–is necessary. Nevertheless, the metallurgical coke market is potentially very large.

For these markets desulfurization and calcining are also of importance. For metallurgical purposes, especially, high sulfur is not desirable. For aluminum electrode manufacture, the material needs calcining as well. Some development work on methods of carrying out the desired desulfurization and calcining is going on, although there is nothing yet available in this respect that can be reported.

In addition, development work on "making big ones out of little ones" is going on. Besides pelletizing and briquetting techniques, a possibility here is the substitution of Fluid coke as a low-volatile or inert constituent in the charge to a by-product coking oven. It is well known that the low-volatile coals generally used for this purpose in the United States are already high priced and the supply is decreasing. Consequently, there is considerable incentive for developing other materials for the purpose.

The U. S. Bureau of Mines is carrying out some laboratory work at present as part of its comprehensive study of new sources of low-volatile and inert components. Preliminary indications are that Fluid coke makes metallurgical coke of definitely improved mechanical characteristics. The size, an important feature in both blast furnace and foundry coke, is improved, and the shatter loss is reduced. Such changes are characteristic of the addition of other inerts, such as by-product coke breeze or anthracite fines. However, use of these additives seriously increases the amount of fines produced in the tumbler test. Fluid coke is unusually attractive in that it appears to give the same advantages without suffering this disadvantage. The decrease in tumbler quality has limited the extent to which coke breeze or anthracite fines can be employed (*3*). Plots showing the effect of using Fluid coke in this way are given in Figure 8.

These data are preliminary, and any definite conclusion as to the suitability of Fluid coke for the purpose must await confirming and broader tests. With the 70,000,000 tons/yr. metallurgical coke consumption in the U. S., however only a few per cent of Fluid coke in this product would represent a large outlet.

Some of the pellets and briquettes which have been made from Fluid coke are shown in Figure 4, and a sample of metallurgical coke made with Fluid coke as a low-volatile charge component is shown in Figure 5. Samples of small carbon electrodes, prepared as small-scale samples of electrodes for use in aluminum manufacture, are shown in Figure 6. These electrodes exhibit excellent strength properties, and have an unusually fine and homogeneous structure on a broken surface.

Conclusions

Fluid coking is economically attractive without realizing more than fuel value on the coke production. A sizable increase in realization can be achieved by selling the coke for high-value specialty uses.

The new Fluid coke product can be transported and stored with the employment of conventional techniques, with some modifications. Information is also available on combustion and grinding of Fluid coke for use as boiler furnace fuel.

At present about 18,000 bbl./stream day of Fluid coking capacity is well under way. About 100,000 bbl./stream day of additional capacity is under consideration.

fluidization

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NO. 2 IN MANAGEMENT SERIES

HOW TO MAKE AN ORGANIZATIONAL PLAN WORK

John L. Hammer, Jr. | Monsanto Chemical Company, St. Louis, Missouri

Others have outlined the principles behind business organization and the application of these principles in the establishment of an organization. Now we come to the difficult part—making the organization work. Before we go any further, I might point out that to my knowledge no organization functions perfectly for the very simple reason that it is concerned with people and not with things. One can expect consistency with most *things* and obtain the same results if conditions remain constant, but people are never consistent and, therefore, despite the uniformity of the conditions surrounding their work will react differently from day to day and sometimes from minute to minute. For such inconsistency we are all thankful, for the unpredictable reactions of our associates make our business life interesting and exciting. Sometimes they make us mad, but if they're proper human beings, they never make it dull.

Describing the Job

J. R. Sargent (*1*) and L. Fish (*2*) have shown how various functions are grouped to assure smoothness and proper flow of authority and responsibility. They have discussed the problems involved in designating the proper people to perform these jobs and assume this authority. Now it must be explained to these people what they are expected to do. Here's where the so-called job description, a definition of responsibility and duties, comes in. And here's where I personally differ from some of the experts, for I blame them, rightly or wrongly, for evolving a language all their own to use in writing job descriptions. As an example, let me quote from a job description I saw recently:

Set up budgets to enable the company's goals and objectives to be realized effectively and efficiently and to revise estimates as they are required periodically.

Wouldn't it be easier to say: "Set up budgets and review them periodically?"

To me it's most important a job description should be written in the plainest, shortest words possible. It's got to tell a fellow to whom he reports, who reports to him, and exactly what is expected of him. Next comes the interview with everyone involved in the plan. Obvisously, the top man on the totem pole can't have a long discussion with everybody on the chart, but every man who has people reporting to him should thoroughly discuss their job descriptions with those immediately below him. Much misunderstanding and consequent grief can be avoided right here if time, patience, and tact are employed in these organizational discussions.

Here is where the "boss" (what a horrid word) can assure the success of the whole operation by obtaining a complete understanding of the job to be done, both by the individual himself and by the organization as a whole. Obviously, a man working in his own little bailiwick will work much better if he understands the goal toward which the whole organization is headed. Here, too, it is very important to impress on each individual the importance of his job to the attainment of this goal. Even the lowest job imaginable is important and should be dignified in the mind of its holder. If a man doesn't think his job essential, then he will never perform it well, and after all, it is good performance all up and down the line that gets the total job done.

Naturally, the organizational chart showing the relation between staff and line functions and the flow of authority is used with the job description to show each man where he fits in the composite picture and what is expected of him. These charts and job descriptions then form the basis for a manual which should include the company's policies which assure uniformity of operation. Personnel policies for the handling of pensions, vacations, hiring procedures, and the like are here as are the rules of the road with regard to the company's approach to suppliers, customers, regulatory bodies, the community, and the world in general. Again let me stress the necessity for brevity and clarity. Give a man signals he understands and let him use his own judgment wherever possible. I have stressed the interpretation of the organizational plan by verbal communication, and I firmly believe this is the best way as

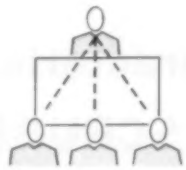
it gives the listener a chance to ask questions, and thus clears away any fog that may arise. Unfortunately, this is not always feasible, in which case the written interpretation that substitutes for the verbal must be very carefully conceived so that a complete understanding is conveyed.

Functional Operation and the Human Being

After all this, everyone should know the score and the organization should function as perfectly as a bunch of human beings can make it (that's not going to be 100%, mind you). One might think he could sit back and let the whole thing percolate smoothly along. Such is not the case. First thing you know, somebody decides he'll spend the rest of his life on the farm or on a sandy Florida beach, so you have to move the whole organization around in order to fill his place. It's like checkers—each move entails another one. Or, you find that some employee is just naturally smart as the dickens, so you have to look for a spot that will really utilize his talents to the utmost. Or, maybe after all this careful planning, the proverbial round peg shows up in the square hole. How do you get him into a round hole where he belongs?

All this adds up to the necessity of constantly thinking about personnel development–development for advanced executive responsibility and authority or the recognition of abilities and the proper utilization of these assets. Maybe a man goes up the ladder in a vertical line. More than likely he will take a number of horizontal swings before he reaches the top. These are necessitated by the need for experience in fields outside his chosen career. A stint in the plant is invaluable to a salesman. A purchasing agent who has been out on the road selling is a better man for this experience. A couple of years in a staff job never hurt a line man or vice versa. It all means making a man understand the other fellow's problems and thus make him better able to handle his own. Unfortunately, it is not always possible to move up a step to gain this experience–hence, the horizontal moves are necessary. Well, a good boss tries to make these moves and a good employee welcomes them because only in this way can he develop into the top-notch executive who is always so badly needed.

There has been a lot of talk about charts and job descriptions and all these other things that seem to limit a man to a very specific niche. Let's go back again to the humon element in this whole picture. All these little boxes and lines look pretty on paper, but really if any man actually fits right into his assigned place 100%, I'm not certain anyone would want him. He'd be an automaton. So we have to remember that imagination and ingenuity and just plain old human cussedness will have people hopping out of their boxes and crossing lines and generally messing things up. Mr. Sargent (*1*) touched on this subject when he pointed out that any member of an organization should have access to any other member. He emphasized that only in this way could there be an interchange of ideas and information–a cross pollination if you will–which is so necessary to the success of any company. He laid down only one rule—orders and instructions should follow the lines of authority as set forth in the organization chart.



Communications

While we're on the subject of cross-pollination, let's think a minute about communications. Certainly communications is the most hackneyed word in business today. Everybody is talking about it and most people feel they are expert on it. Actually, they are because it's really the simple business of sharing one's knowledge and experience with others—something most of us do unconsciously from childhood. So I need not say it is important that each person in an organization share the outstanding occurrences of his business life, and his ideas and aspirations with his fellow-workers. For fear of beating a tired old horse to death, I'll only say a little more about communications and that is that it is possible to over-communicate. If you share all the minor details of your job with your superior or your subordinates, you'll have them constantly on your neck asking why you did it the way you did, or you'll be boring them to death. There's a fine line to be drawn, and each man has to work that out for himself. That is where a good top executive comes in. He must see that all this potential imagination and intelligence are encouraged and utilized while the instructions flow along the predetermined stream.

Perhaps the most important part of implementing an organizational plan lies in the proper handling of the delegation of authority. This has already received considerable attention, and likely it is obvious to all. However, delegation has another result, equally important. It encourages the man below by giving him a feeling of belonging that induces him to put forth his best efforts. We'll all agree that delegation is a fine thing; we are all for it, but then comes the question, how do we accomplish it? Actually, I believe it is harder for a man to delegate his responsibilities and authorities to another than it is to do most anything else in business. Once again I refer back to Mr. Sargent who elaborated on this point. People just don't like to admit that their subordinates possess the experience or judgment that they do. Unfortunately, there is no pill you can give a man that will make him delegate. As far as I know, you just have to talk him into it and show him by example that it works.

Use of Committees

In almost every discussion of organizational planning, the subject of committees raises its ugly head and is responsible for more arguments than any other topic in the field. They are wonderful things when used properly. There is no better way for a group of people to keep informed on company activities than to sit on a committee that is broadly concerned with the whole operation; but it's awful hard for a committee to make a decision. It is a fine sounding board, but a poor executive. Committees should be used to assemble various points of view and to keep people informed, but the decision-making must rest in the hands of the executive to whom it has been assigned.

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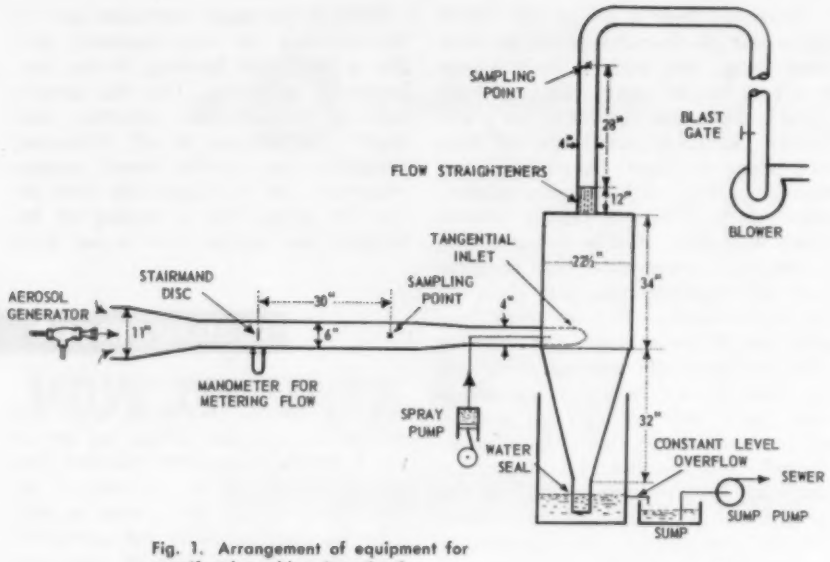
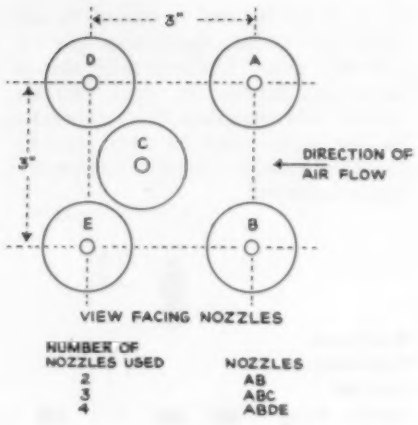
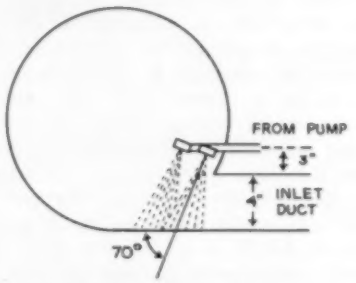


Fig. 1. Arrangement of equipment for centrifugal scrubber investigation.





CROSS SECTION OF SCRUBBER AT INLET LEVEL SHOWING LOCATION OF SPRAY NOZZLES

performance characteristics of CENTRIFUGAL SCRUBBERS

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The present study was undertaken at the suggestion of the Atomic Energy Commission* to determine if a simple, inexpensive but efficient wet collector could be developed for use at A.E.C. sites. For radioactive aerosols, wet collection units may permit continuous and remote-control removal. In addition to permitting control of the contamination level in the collector, it is sometimes easier to handle and dispose of liquid than of solid wastes.

An additional objective was to obtain information on the fundamental principles of wet collection to develop criteria for predicting and improving the performance of practical devices. Scrubbers, washers, and their various modifications are widely used in industry for cleaning and cooling gases. Although commercial equipment is available which combines scrubbing with almost every method of dust and mist collection, there are limited accurate performance data as guides in the selection of suitable devices for specific problems. Available information usually represents results from specific installations and may not be applied with confidence to different sizes or modifications of equipment or to the treatment of other aerosols.

This investigation is primarily concerned with the performance characteristics of two wet separating devices: (1) an experimental cyclonic scrubber and (2) a commercial dynamic spray scrubber (Hydro Volute scrubber †). In spite of a wide dissimilarity in their appearance and operation, they respond, in most cases, in an entirely analogous manner to similar changes in operating conditions. Differences, where they occur, are valuable in further revealing the fundamental principles governing the operations of wet collectors.

Variations in efficiency due to changes in water spray rate, dust loading, spray droplet size, and air flow rate were among the principal items investigated. In addition, the flow pattern and dust distribution in the cyclone scrubber, and the effect of rotor speed on efficiency (for the dynamic scrubber) were of direct interest. Another objective was to evaluate the effectiveness of these types of air cleaners with a number of aerosols and to compare their performance with that of other devices (wet and dry) which might be employed for similar service.

The advantages and disadvantages of wet vs. dry collection have been summarized by Silverman (*1*) and others (*2*).

These general observations may be applied to specific situations to aid in the selection of air- and gas-cleaning equipment. Suitable corrosion-resistant

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This study was made under contract between the U. S. Atomic Energy Commission and Harvard University. The opinions expressed in this paper are those of the authors and do not necessarily reflect the views of the United States Atomic Energy Commission.

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Table 1.—Rotational Speed and Power Requirements of 10-S Hydro Volute Scrubber

Static pressure, water, in.	0	1	2	3	4	5	6	7
Rotor speed, rev./min.	1945	2050	2165	2282	2415	2550	2670	2800
Hp.	2.08	2.46	2.74	2.88	3.14	3.41	3.72	4.05

materials of construction are now available to handle many types of contaminants in wet-type collectors if adequate water supplies are available.

Theoretical Considerations

Application of wet methods to the collection of dust and mist is effected by particle conditioning and particle deposition. These may occur simultaneously, stepwise or the wet process may be concerned only with conditioning (and subsequent collection by a dry-type device) or only with particle collection (without preliminary conditioning treatment).

Particle conditioning is the process of increasing the effective size of fine particles so they may be more readily precipitated with less efficient air cleaners. Particle size is increased by (1) spontaneous and induced agglomeration, a process whereby two or more particles, not necessarily of the same material, make physical contact and adhere and (2) condensation around dust particles or droplets which act as nuclei when the gas passes through its dew point (evaporative cooling or by steam addition).

The application of wet methods as an aid in collection (exclusive of the conditioning function) are relatively minor and are concerned primarily with dust disposal. In many types liquid flows over collection surfaces in the form of a thin film to wash the collected dust into a sump to prevent re-entrainment. When a gas is dispersed by bubbling it through a liquid, precipitation may take place by gravitational settling and Brownian diffusion of the particle from the gas film to an adjacent liquid surface. Devices, such as the Theissen Disintegrator (*3*), are capable of dispersing the gas into elements having a thickness approaching that of the particles to be separated, are required to make simple gas washing effective; but these are expensive and consume large amounts of power.

The most effective and economical application of wet processes is their use to condition particles by agglomeration. An example of this is the attachment of a 5μ diameter dust particle to a liquid droplet 50μ in diam., thereby increasing its apparent mass nearly 1,000-fold for collection purposes.

Collisions between micron- and submicron-sized water droplets are inelastic and, because of Van der Waals forces, the agglomerates resist redispersion. For this reason the addition of wetting agents to wet particulate collectors does not increase removal efficiency. Tests by Feild (*4*) with the venturi scrubber using soluble and insoluble particles indicated that solubility of the aerosol particle is not a factor in the effectiveness of the scrubber although concentrated mist droplets, such as sulfuric acid, may grow in size by the absorption of moisture when passing through a humid chamber.

Deposition of dust or mist on spray droplets may be by one or more of the following mechanisms: inertia and interception, Brownian diffusion and electrostatic forces. Ranz (*5*), Johnstone and Roberts (*6*) and a previous report by some of the present authors (*7*) have discussed these separation forces at length.

A separation mechanism which may occur in spray-type wet scrubbers is entrainment, i.e., as droplets move through the air stream toward the collecting surface, they entrain a small amount of air in their wake. Particles present in this entrained air are brought closer to the collector wall, thereby increasing their chances for capture. Turbulence is an additional factor for bringing particles closer to the walls of the collector.

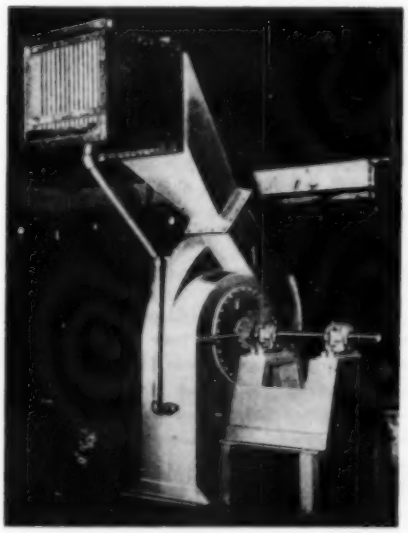
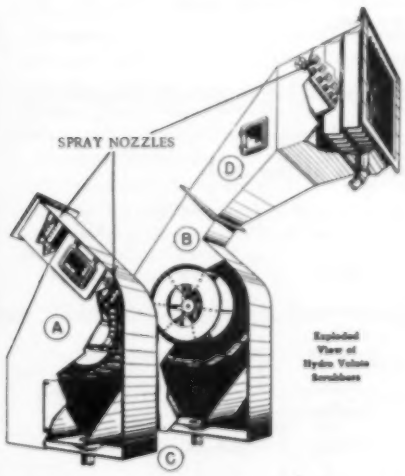


Fig. 2. Hydro Volute scrubber.



A. volute or precleaner section, showing water spray header, spray nozzles, and slotted scroll; B. fan section, showing impeller and slotted scroll; C. sludge removal outlets; and D. eliminator section, showing flooding nozzles and zigzag plates.

COMMERCIAL WET COLLECTORS

Because detailed descriptions and illustrations of most basic types of commercial scrubbers may be found in recent books (*3*, *8*), and in numerous articles such as those of Brandt (*2*), Witheridge (*9*), Ekman and Johnstone (*10*), Montross (*11*), Lamoreaux (*12*), and Kleinschmidt and Anthony (*13*), further details on wet collectors have been omitted from this paper.

Experimental Equipment

A. EXPERIMENTAL CYCLONE SCRUBBER

A diagram of an experimental scrubber is shown in Figure 1. Waste water from the scrubber was drained into a 55-gal. drum placed under the cone. A constant level overflow on this drum maintained a uniform head so that the height of water sealing the scrubber

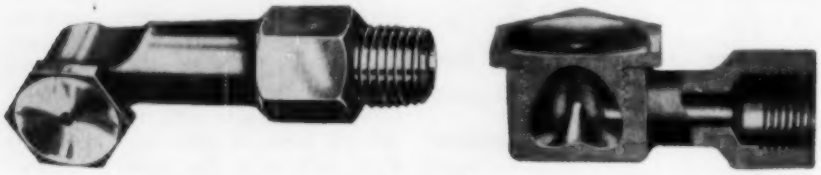


Fig. 3a.* Low pressure hydraulic nozzles (not to scale). Left, ¼-in. shank, 1/32-in. orifice; right, cutaway view, ⅜-in. shank, 3/16-in. orifice.

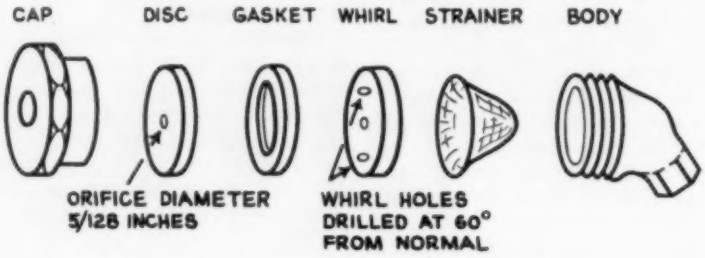


Fig. 3b. No. 3 Bean nozzle—no. 2½ hard center disc.

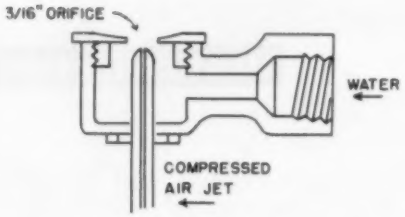


Fig. 3c.* Pneumatic atomizing nozzle.

* Courtesy *Buffalo Forge Co.*

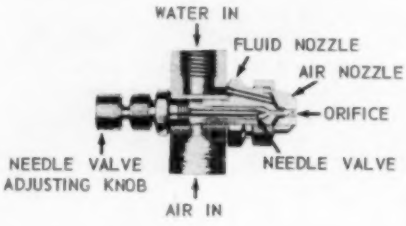


Fig. 3d. Spraying Systems Co. type ¼ JN pneumatic atomizing nozzle. (See (16), (17), and (18)).

Table 2.—Physical Characteristics of Test Dusts

Composition	Median Size by Weight Microns	Standard Geometric Size Deviation	Shape	Specific Gravity	Aerosol Concentrations gr./cu.ft.*
Fly ash	16.0	4.4	Spheres and irregular	Variable	0.1–10
Talc	1.4	1.8	Short needles	2.7–2.8	1.0
Vaporized silica	0.6	1.6	Spheres	2.6–2.7	1.0
Copper sulfate microspheres	2.5	1.7	Spheres	3.6	4×10^{-6}

* Approximate.

cone was constant. Excess water was wasted to the sewer. The entry duct has an 11-in. diam. section to facilitate the feeding of the test dusts. The pressure drop across a disc in the entry duct was used to meter air flow. After the sampling point (5 duct diameters downstream of the disc) the entry contracted gradually to 4 in. before entering the collector. The downstream sampling point was located 40 in. after the exit duct flow straighteners.

B. HYDRO VOLUTE SCRUBBER

Figure 2 is a diagram of the single fan Hydro Volute scrubber used in these tests. Since the impeller functions like a fan, as well as a particle precipitator, its rotational speed (for constant air volume) must be matched to the resistance of the system in which it is placed. For example, to maintain an air flow of 1,000 cu.ft./min., the rotor speed and horsepower requirements for a range of static pressures are as shown in Table 1 (*15*).

The entering air is sprayed (concurrent to air flow) with 24 low-pressure (5 to 15 lb./sq.in.) coarse-droplet spray nozzles at the rate of 5 gal. of water/1,000 cu.ft. of air before it enters the fan inlet scroll. Here centrifugal force precipitates coarse dust and large droplets (containing dust) against the scroll wall. Finer dust and smaller spray droplets are carried into the slotted fan scroll where they are precipitated by the increased rotational velocity of the air, as well as by the dynamic action of the high-speed impeller. After the fan casing there is a wetted 1.5 gal./min./1,000 cu.ft. eliminator section of multiple-bend zigzag plates to rid the discharge of liquid droplets.

With the use of low-pressure hydraulic spray nozzles, the scrubbing liquid may be recirculated after a short settling period without plugging the nozzle orifices. In all of these tests, however, water was sent to waste, and no data were collected to determine the effects of recirculation on efficiency.

C. SPRAY NOZZLES

A variety of hydraulic and pneumatic nozzles was used during this investigation to determine the influence of spray droplet size and size distribution on collector performance. These are shown in Figures 3 (*a*, *b*, *c*, and *d*).

D. TEST DUSTS AND AEROSOL GENERATOR

Table 2 indicates the test materials used in this investigation and lists their important physical properties. As the table indicates, fly ash is a relatively coarse dust with a significant weight fraction retained on a 325-mesh sieve. It is composed of nonhomogeneous materials and contains a wide range of particle sizes. Talc and vaporized silica are finer in size, homogeneous in composition, and nearly of uniform size. They represent types of dust which might be collected from grinding or bagging operations. Copper sulfate microspheres are an artificial dust with a size distribution approximately the same as talc. They permit a comparison of

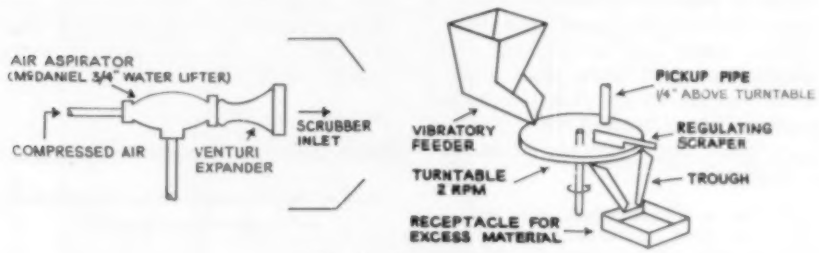


Fig. 4. Dust generator.

collection efficiency for soluble and insoluble particulates.

The test dusts (with the exception of copper sulfate microspheres) were uniformly dispersed with minimum agglomeration by the use of the apparatus shown in Figure 4. Dust is fed to a rotary turntable from a vibratory feeder. The amount of material becoming airborne is controlled by the regulating scraper which allows material to pass at a uniform rate. Excess material falls from the turntable into a receptacle from which it may be returned to the feeder. The uniform ribbon of dust passing the scraper is raised in a pipe by induced air from an aspirator. A ¾-in. McDaniel * water lifter with venturi section is satisfactory. Primary air is supplied to this aspirator at 10 to 25 lb./sq.in. gauge depending on how much dispersing force is needed. The high degree of turbulence (and the resulting shear forces) present in the expanding section of the aspirator breaks agglomerates and disperses the aerosol uniformly. By scrapper adjustment, wide variations in loading are obtained. In this study loadings from 0.03 to 15 gr./cu.ft. were used: a 500-fold range.

Copper sulfate aerosols were generated from spray droplets of atomized copper sulfate solution which were dried and fused by a method described in a previous report (7).

E. SAMPLING AND ANALYTICAL METHODS

Sampling equipment used with the cyclone scrubber is shown in Figure 5. For the Hydro Volute scrubber, the duct-sampling equipment used for field sampling was employed. This was described in previous reports (7, 19). Both sets of sampling equipment are similar; the only significant difference is in the location of the filter thimble; for the field sampler it is located in the probe and for the equipment used in the cyclone scrubber studies, an inlet probe is placed before the filter. With the latter arrangement it is possible to deposit significant quantities of dust in the probe tube. To minimize this difficulty, the sampling probe was rapped after a sample was taken prior to disassembly, in order to dislodge talc which may have deposited within the probe. This material fell into the thimble. Several probes were weighed before and after use, and again after rapping. It was found that less than 1 mg. of talc was left in the probe after rapping. In some cases the probes were washed and the wash water allowed to filter through the thimble. This was done when moisture entered the probe and created a moist talc deposit difficult to remove by rapping.

Inlet and outlet samples were taken simultaneously and all were collected isokinetically. Efficiency was determined by the gravimetric method described previously (7).

Sampling for copper sulfate microspheres was performed with the aid of electrostatic precipitators, and the total quantities of copper collected were determined chemically by the sodium diethyl dithiocarbamate method (7).

Centrally located discs (14) were placed up- and downstream of the Hydro Volute and upstream of the cyclone scrubber to give a uniform dust and velocity profile at the sampling stations. A central disc was deemed inadvisable following the cyclone because of the vertical flow normally present in the exit duct. Therefore, 1½-in. diam., thin-wall tubes, 12 in. long, were inserted in the exit duct to act as flow straighteners. A static pressure traverse at the outlet sampling point revealed that static pressure was constant across the duct cross section at this point, the effect of the vertical flow having been smoothed out by the straightening section. Air flow rate through the cyclone and Hydro Volute collectors was adjusted by means of blast gates in the exit duct.

The pressure loss across the cyclone scrubber was measured between a static tap in the entry duct (16 in. upstream of the collector) and a static tube placed in the exit duct 40 in. downstream of the collector. No correction for velocity was necessary because the areas of the up- and downstream sections were equal.

Energy requirements of the Hydro Volute scrubber were estimated by measurements of the wattage consumption of the 3-hp. motor used to drive the impeller. Total air flow was measured by using the centrally located flow-straightening disc in the entry duct as an orifice meter after calibrating it with a standard Pitot-static tube traverse.

* Walworth Company, New York.

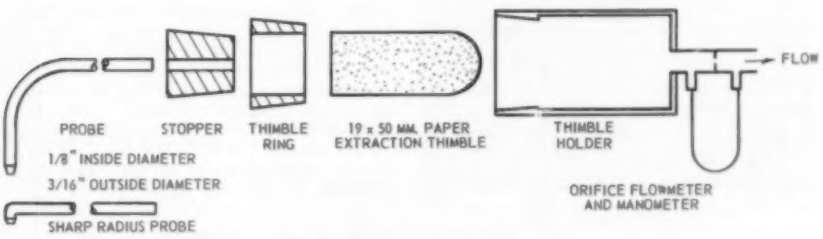


Fig. 5. Sampling equipment.

Tests Results

A. COLLECTION EFFICIENCY

1. Effectiveness of Wet Operations

Increases in collection efficiency due to wet operations were determined for a variety of conditions. This type of information is most valuable for the cyclone scrubber, as a cyclone precipitates dust even when dry. With this device the sprays act primarily, if not exclusively, as particle conditioners. In the case of the Hydro Volute scrubber water has an additional and important function of trapping dust which has been precipitated onto the walls and impeller surfaces by centrifugal force (or by the dynamic action of the blades), and washing it into the sump for disposal.

Since many collectors which might be classified as wet scrubbers use water only for the purpose of wetting the collector walls or baffle plates to increase dust retention, the effectiveness of wetting the walls of the cyclone (without the introduction of spray droplets into the air stream) was investigated to determine the role wetted surfaces play in dust collection in inertial-type collectors.

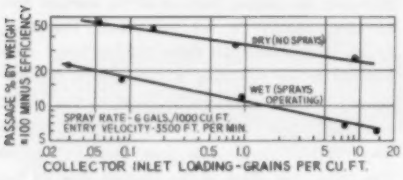


Fig. 6. Efficiency characteristics of experimental centrifugal scrubbers (wet and dry).

a. Cyclone scrubber

(1) Application of water as spray droplets. A series of wet and dry runs was made with the cyclone using two full-cone, high pressure, hydraulic nozzles (Figure 3b) at 400 lb./sq.in. Water rate was 6 gal./1,000 cu.ft. of air, air rate, 270 cu.ft./min., and the test material was micronized talc. It may be seen from Figure 6 that the results can be approximated by two straight lines although neither can be straight for its entire length since it must, at some point, become asymptotic to the hundred percent passage line. Efficiency of the collector, when operated wet, ranges from 78% (at a loading of 0.03 gr./cu.ft.) to 94% (at 18 gr./cu.ft.). Efficiency of the collector, when operated dry, varies from 46% (at a loading of 0.5 gr./cu.ft.) to 75% (at 10 gr./cu.ft). It is apparent that the dust loading to be supplied to the collector must be known if the performance of the apparatus is to be predicted.

These curves emphasize the differences between the efficiency of the scrubber dry and the efficiency when operated wet. Since the lines are nearly parallel, the relative effect of the water, in terms of reduction of effluent loading, is nearly constant. The dry effluent is 2.8 times the wet at a loading of 0.1 gr./cu.ft. and 3.6 times at a loading of 10.0 gr./cu.ft. In terms of relative performance the effect of the sprays is slightly greater at higher loadings. This indicates, as predicted from theory, that there are a greater number of collisions as the number of dust particles increases. With dry operation an increase in efficiency with loading can be attributed to collision between particles and subsequent agglomeration. These agglomerates, being heavier than any of the particles of which they are composed, are easier to trap than are discrete, unitary particles. With wet operation this phenomenon also takes place. However, the rate of collision is somewhat greater as is shown by the slope of the wet operation line (being —0.20 compared to the slope of the dry line which is —0.15), indicating that some other effect than agglomeration of dust is contributing to increased efficiency when water is sprayed. The greater rise in efficiency with loading (under wet conditions) is a result of an increase in the relative number of collisions between particles and droplets.

(2) Application of water as a film on the cyclone walls. The relative efficiency of the cyclone when dry and with walls wetted by means of a circular drip tube located around the upper edge of the cyclone body was investigated. The wetted wall tests were made with a water rate of 4.5 gal./1,000 cu.ft. and loadings of micronized talc of about 1 gr./cu.ft. The results are summarized in Figure 7.

At low entry velocities wet and dry efficiencies were substantially equal, but at 4,000 ft./min. entry velocity the difference was small but significant, indicating that even with small particles there is a dynamic equilibrium in dry cyclones between deposition on the walls by centrifugal force and re-entrainment by rebound and eddy formation at irregularities on the collector surfaces. The differences between dry- and wetted- wall operation would doubtless be greater if there were larger particles (i.e., more nearly in the usual particle-size range for equipment of this nature) in the test dust. From these tests it was concluded that the wetted walls accounted for only a small part of the increased efficiency noted when the cyclone was operated with high pressure sprays located at the inlet.

b. Hydro Volute Scrubber

The relative efficiency of this device, when operated dry and wet, is compared in Table 3. Impeller speed was held constant at 2,635 rev./min., and the dust loading was 0.1 to 1.5 gr. of fly ash/cu.ft. of air. These results show that the scrubber is ineffective when operated without sprays.

This should not be interpreted as an indication that the dry mechanical types are equally ineffective, as these employ mechanisms other than wetted walls and wet-impeller blades for capturing the precipitated dust.

2. Effect of Water Rate

a. Cyclone Scrubber

One of the basic considerations in the study of a wet collector is the amount of water required to give satisfactory performance. A series of tests was made with two, three, and four high-pressure hydraulic nozzles placed at the cyclone entry to study the effect of water rate variation. Dust loading was held close to 1 gr./cu.ft. of talc and an entry velocity of 3,500 ft./min. was maintained during all these tests. Results are shown in Curve B of Figure 8. The portion of the curve between 0 and 4 gal./1,000 cu.ft. of air has been shown with a dotted line to indicate its expected position. An optimum water rate for use in a collector of this type can be selected from a curve of this sort. As the water rate increases above 6 gal./1,000 cu.ft., the curve rapidly approaches horizontal, indicating that further increases in water rate do little or nothing to enhance performance and serve only to increase the power requirements (as well as contribute to waste water disposal problems).

The optimum water rate is greatly influenced by operating and construction details, although for each situation the trend is similar.

This is illustrated by Curve C of Figure 8 which shows the same general shape and trend as Curve B but is quantitatively quite different. It is the result of different operating conditions although the same test dust and dust loadings were used, i.e., an entry velocity of 4,000 ft./min. and three $^{3}/_{16}$-in. orifice, tangential, hollow cone hydraulic nozzles placed at right angles to flow at the cyclone entry. For these experiments the water rate was altered by varying nozzle pressure. As pointed out previously, this introduces an additional variable in that droplet size decreases and flow increases as pressure rises so that some part of the efficiency increase is due to the introduction of larger numbers of small droplets. Nevertheless, the curve shows the characteristic changes, i.e., a slow increase in efficiency as water rate increases from zero up to a critical point beyond which efficiency rises rapidly, and then follows a rapid leveling of the curve to almost constant efficiency. (This latter part of the curve is only partially developed in the case of Curve C and the leveling off is somewhat obscured by the effect of decreasing spray drop size).

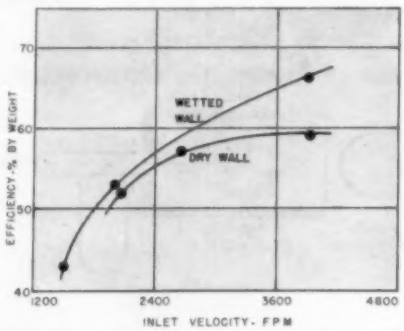


Fig. 7. Efficiency of cyclone with wetted walls.

Table 3.—Wet-and-Dry-Collection Efficiency of Hydro Volute Scrubber

Air Volume cu.ft./min.	Efficiency—Per Cent by Weight Dry	Wet
600	25.6	96.5
800	19.8	97.4
970	25.4	97.8

b. Hydro Volute Scrubber

The effect of water rate on collection efficiency of the Hydro Volute scrubber

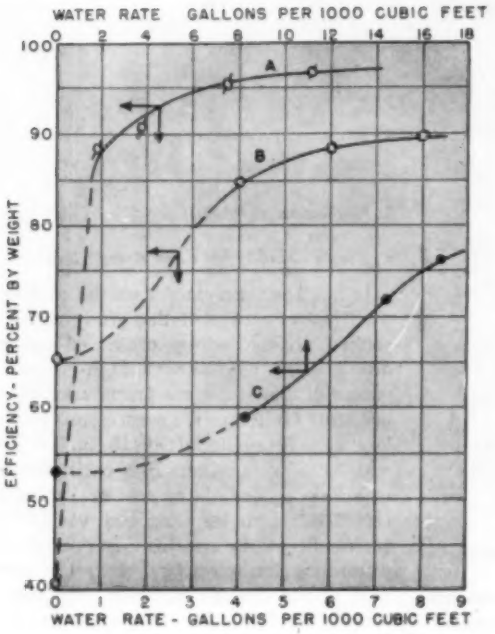


Fig. 8. Effect of water rate on centrifugal scrubber efficiency.

Curve No.	Collector	Nozzle	Dust	Loading gr./cu.ft.	Entry Vel. ft./min.	Nozzle Location
A	Hydro Volute	Hydraulic w/ 1/16-in. orifice	Flyash	1	2,635*	Entry
B	Cyclone	400 lb./sq.in.	Talc	1	3,500	Entry
C	Cyclone	Hydraulic w/ 3/16-in. orifice	Talc	1	4,000	Entry

* rev./min.

was determined with fly ash at loadings ranging from 1 to 1.5 gr./cu.ft. for a rotor speed of 2,635 rev./min. and an air flow rate of 900 cu.ft./min. Four to twenty-four low-pressure tangential nozzles (Figure 3a) with 1/16-in. orifice diameter were used at 3.6 lb./sq.in. for this study. Table 4 indicates the effect of water rate on collection efficiency. Water rate was varied by changing the number of nozzles in service rather than through changing nozzle pressure.

Data of Table 4 are represented graphically as Curve A in Figure 8 to demonstrate the great effect on efficiency of the Hydro Volute scrubber of even a small addition of water. In comparison with the curves representing the cyclone scrubber, only the flat high efficiency sector of the curve is recognizable. This is in agreement with observations in Section 1 (above) that in the Hydro Volute scrubber water serves the dual function of (a) particle conditioning and (b) removing and disposing of precipitated dust. When operated dry this device has inadequate dust-disposal facilities.

As was noted for the cyclone scrubber with high-pressure nozzles, the rate of increase in efficiency becomes very small after an initial rapid rise and the effect of further applications of water is largely wasted in terms of improved dust collection.

3. Effect of Air Flow Rate

The efficiency of an inertial collector is directly related to air velocity (and hence particle velocity), higher flow rates usually resulting in higher efficiencies as well as in higher power requirements.

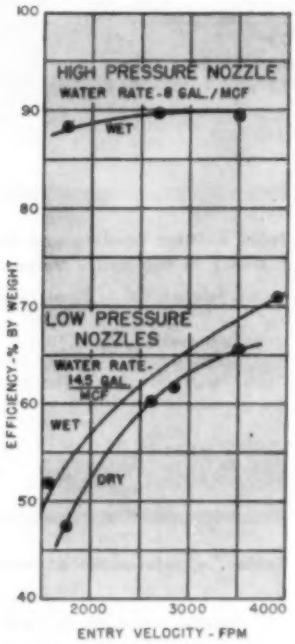


Fig. 9. Effect of entry velocity on efficiency of centrifugal scrubber (wet and dry).

a. Cyclone Scrubber

For cyclone-type collectors with tangential inlet, flow rate is most conveniently expressed in terms of entry velocity. A series of runs was made wet and dry to compare the relative effect of variations in entry velocity. For one such study the wet runs were made with 400 lb./sq.in. hydraulic nozzles positioned to spray across the entry section of the cyclone (as shown in Figure 1) and loadings of about 1 gr. of talc/cu.ft. of air as the test dust. Water rate was maintained at 8 gal./1,000 cu.ft. of air by maintaining nozzle pressure constant but varying the number of nozzles. Results are shown graphically in Figure 9 where it may be seen that dry efficiency (Curve C) increases rapidly with increase in entry velocity whereas wet efficiency remains almost constant over the range tested (Curve A). As was noted previously, the effect of wet operations is more favorable at lower entry velocities, but wet efficiency (with high pressure nozzles) is greatly superior in each case.

Similar experiments were conducted with low-pressure hydraulic nozzles (orifice diameter, 3/16 in.) in place of the high-pressure sprays. Water rate was maintained constant at 14.5 gal./1,000 cu.ft. of air with a nozzle pressure of 25.5 lb./sq.in. Efficiency rose from 52 to 71% as entry velocity increased from 1,500 to 3,900 ft./min. (Curve B, Figure 9). The low-pressure sprays were not so effective as the high-pressure ones, but in this case, also, efficiency increased with increasing air velocity.

b. Hydro Volute Scrubber

The effect of air flow rate in dynamic collectors must be evaluated in terms of impeller speed. Table 5 compares collection efficiency over a wide range of air flows for a number of impeller speeds (read Table 5 from top to bottom). Water rate was maintained constant at 5 gal./min. and fly ash (at loadings of approximately 1 gr./cu.ft.) was the test material.

At the lower flow rates there is a sharp rise in efficiency as air volume increases (at constant impeller speed). This would indicate that particle removal by centrifugal force and impingement on the wet walls of the scroll are more significant factors than impingement of particles on the blades of the high-speed impeller although both methods of collection contribute to the over-all effectiveness of the collector.

(1) Effect of impeller speed. Since the impeller functions as a fan as well as a particle precipitator, its rotational speed (for a constant air volume) must be matched to the resistance of the system in which it is placed and should be regulated as low as possible for operation at minimum cost. The effect on collection efficiency of changes in rotor speed for various air flow rates is shown in Table 5. There is a small but

Table 4.—Effect of Water Rate on Efficiency of Hydro Volute Scrubber

Water Rate gal./1,000 cu.ft.	Collection Efficiency % by weight	Water Rate gal./1,000 cu.ft.	Collection Efficiency % by weight
0	40.9	3.70	95.5
0.93	88.5	5.56	96.8
1.86	90.4		

Table 5.—Collection Efficiency of Hydro Volute Scrubber

(Water rate 5 gal./min.—Loading 1 gr./cu.ft.)

Air Volume cu.ft./min.	Per Cent Collection by Weight			
Impeller Speed, rev./min.	1,180	2,175	2,635	3,170
400	82.9	81.3	86.4	.....
650	.....	93.1	94.4	96.2
900	.....	.....	96.8	96.8
1,050	.....	.....	97.8	.....
1,120	.....	.....	.....	98.4

significant increase in efficiency with increasing rotor speed (reading table from left to right) at all air flow rates tested, but rotor speed does not appear to be as significant a factor, for example, as total air flow in determining collection efficiency.

4. Effect of Dust Loading

a. Cyclone Scrubber

Figure 6 and the discussion above on the effectiveness of wet operations emphasize the importance of dust concentration in separation efficiency of inertial collectors. By the nature of their mode of operation inertial collectors tend to concentrate the dust as a first step in the separation process and this affords an opportunity (by crowding the particles together) for agglomeration and subsequent deposition of fines which have become attached to large particles or clumps. Larcombe (*20*) observed this behavior with dry cyclones over a wide range of dust loadings and his results are in accord with those shown in Figure 6.

b. Hydro Volute Scrubber

Table 6 indicates that the dynamic scrubber shows a direct relationship between dust loading and collector efficiency which is in qualitative agreement with the results obtained with the cyclone scrubber.

Over-all efficiency on a weight basis increased from 94.6% to 98.2% when loading increased from approximately 0.1 to 10 gr. of fly ash/cu.ft. of air; all else remained constant. (Water rate was 5.55 gal./1,000 cu.ft. and rotor speed, 2,635 rev./min.)

Table 6.—Dust Loading and Collector Efficiency in the Hydro Volute Scrubber

(Air Volume: 900 cu.ft./min. Rotor Speed: 2,635 rev./min.)

Dust Loading (Fly ash) gr./cu.ft.	Efficiency Per Cent by weight
0.12	94.6
0.63	95.8
1.65	96.8
9.72	98.2

5. Application of Water

a. Nozzle Characteristics and Droplet Size

It has been indicated that the nozzles used in the course of this study can be ranked in ascending order of mean droplet size as follows: high-pressure pneumatic, low-pressure pneumatic, high-pressure (full cone), low-pressure (hollow cone) tangential: 1/16 in. orifice and 3/16 in. orifice. For each nozzle mean drop size decreases as pressure increases. Droplet size was varied in each collector by substituting nozzles of different characteristics and (in the case of the cyclone scrubber) by operating the 3/16 in. orifice tangential nozzles at different hydraulic pressures.

(1) Cyclone Scrubber. Figure 10 shows the effect of changing spray droplet characteristics by (a) increasing nozzle pressure and (b) by changing nozzles. Although there are variations

Table 7.—Performance of Hydro Volute Scrubber with High- and Low-Pressure Sprays

900 cu.ft./min. and 5.5 gal. of water/min.

(Impeller Speed equals 2,635 rev./min.; dust loadings, approximately 1 gr./cu.ft. of air)

Test Aerosol	Efficiency—% by weight: Low Pressure Tangential Nozzles	High Pressure Hydraulic Nozzles
Fly ash	96.8	99.6
Talc	73.2	95.0

Table 8.—Effect of Nozzle Location on Cyclone Scrubber Performance

Test No.	No. Nozzles	Position	Water Pressure lb./sq.in.	Water Rate gal./ 1,000 cu.ft.	Cyclone Resistance in H_2O	Dust Loading gr./cu.ft.	Efficiency per cent by weight
1	3	Directed down at inlet near entry wall	25.5	15.9	2.6	1.17	54.8
2	3	Right angles at inlet	25.5	15.9	4.6	1.09	70.9
3	3	Countercurrent to flow in inlet duct	25	15.3	9.2	1.00	82.0
4	2	Countercurrent to flow in inlet duct	50	14.5	9.5	1.11	84.7
5	1	Countercurrent to flow in inlet duct	45	7.0	...	1.09	76.3
6	1	Concurrent with flow in inlet duct	45	7.0	...	1.22	72.0
7	1	Concurrent in inlet duct followed by 2 Saran screens supported by a coarse wire screen	45	7.0	...	0.951	80.2

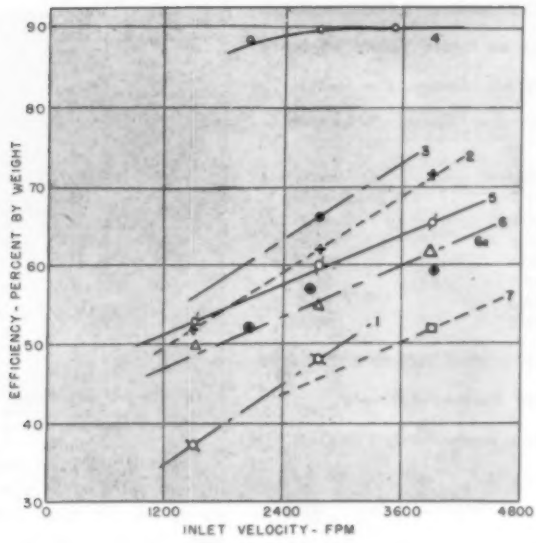


Fig. 10. Effect of size of spray droplets.

Curve	Type of Nozzle	Pressure (lb./sq.in.)
1	Hydraulic, 3/16-in. orifice	8
2	Hydraulic, 3/16-in. orifice	26
3	Hydraulic, 3/16-in. orifice	33
4	John Bean	400
5	Hydraulic, 3/16-in. orifice	26 (right angle to flow)
6	Buffalo, pneumatic	20
6a	Dry, empty cyclone	—
7	Dry, nozzles in place	—

in water rate which tend to influence these results to some extent, it is believed that the effects of changes in droplet size stand out quite clearly. Curves 1, 2, and 3 of Figure 10 illustrate the effect of nozzle pressure (i.e., droplet size and water rate) on scrubber efficiency for low-pressure hydraulic nozzles located near the cyclone entry at right angles to air flow. Efficiency increased with increasing nozzle pressure. Also shown in Figure 10 are the efficiency curves obtained when using other types of nozzles. In addition, points representing dry efficiency are also included for comparison. It may be seen that efficiency with three low-pressure hydraulic nozzles in place but the water turned off was 52% at an entry velocity of 3,900 ft./min. This is considerably below the dry efficiency of the cyclone when tested with no spray nozzles installed. The wet efficiency of the cyclone at 8 lb./sq.in. is also less than the dry efficiency of the empty cyclone. This peculiar result is due probably to the entry vane effect of the nozzles placed in the path of the incoming air. This is in agreement with studies on conventional cyclones which show that entry vanes decrease the velocity of the spinning gases in the cyclone body. The vane effect should be taken into account in the design of cyclone scrubbers.

It may also be noted from Figure 10 that the coarse spray of the low-pressure tangential hydraulic nozzles gave higher efficiencies for the same entry velocity and dust loadings than the fine pneumatic nozzle sprays. This indicated that the droplets from the pneumatic nozzles are too small to sweep the area in front of the inlet (they were carried away with the air stream). Droplets from coarse flooding-type nozzles are large enough to penetrate the air stream and reach the outer cyclone wall, but in comparison with high-pressure sprays (efficiency approximately 90%) too few droplets are formed for effective dust removal. As a matter of interest it may be noted that wet efficiency with all except the high pressure sprays was only moderately superior to dry efficiency, although it was higher than dry efficiency with the spray nozzles in place.

(2) Hydro Volute Scrubber. Similar experiments were carried out with the commercial collector by the use of low-pressure tangential nozzles of 1/16 in. orifice diam. and high-pressure hydraulic nozzles at approximately the same water rates. Table 7 indicates the results for two different aerosols. In both instances efficiency is significantly greater for the high-pressure nozzles. As in the case of the cyclone scrubber, too few droplets are formed with the coarse spray (as well as their being too large for effective particle capture) in comparison with the high-pressure nozzles.

b. Location of Nozzles

(1) Cyclone Scrubber. Effect of nozzle location on wet cyclone performance with low-pressure hydraulic spray nozzles (Figure 3a) is summarized in Table 8. The nozzles noted in the first item in the table were placed 1 ft. above the inlet and were directed downwards in an attempt to send the spray toward the wall where the dust concentration is highest. Efficiency and resistance were both low. Efficiency was increased 16% by placing the nozzles at right angles to the inlet but resistance also increased (Test 2). When the nozzles were placed countercurrent to flow in the cyclone inlet duct (Test 3), efficiency increased another 11% and the resistance of the system doubled.

From Table 8 it may be seen that highest efficiencies (and resistances) occurred with the nozzles placed in the inlet duct. With two nozzles placed countercurrent to flow, (water rate of 14.5 gal. of water/1,000 cu.ft. of air and water pressure of 50 lb./sq.in.) an efficiency of 84.7% was obtained (Test 4). This compares with 90% with solid cone 400 lb./sq.in. nozzles (Figure 3b) and the same inlet velocity (but cyclone resistance with nozzles in the entry duct was about 1 in. higher and water rate 6 gal./1,000 cu.ft. greater). With low-pressure nozzles, however, pumping requirements are less and water can be recirculated with less danger of plugging the nozzle orifice than with the high-pressure ones.

Several runs were made with ⅛-in. mesh Saran screens inserted in the cyclone inlet duct a few inches downstream of a low-pressure hydraulic nozzle spraying concurrent with air flow (Test 7). The screens were included to break up large water droplets and spread the water by surface tension effects. The insertion of two screens increased efficiency 8% (from 72 to 80.2%, Tests 6 and 7), but also resulted in a higher resistance. Water rate was relatively low (7 gal./1,000 cu.ft.) and there was no accumulation of material on the screens.

(2) Hydro Volute Scrubber. Location of nozzles was not changed in the Hydro Volute scrubber, but the effect of spraying concurrent and countercurrent to air flow was investigated with both low-pressure and high-pressure hydraulic nozzles. Table 9 is a summary of data collected at various water rates with fly ash as the test aerosol.

From these results it may be seen that in this device countercurrent spraying is much more effective than spraying with the air stream because there is (a) more intimate contact between droplets and air, (b) greater relative velocity between dust and droplets, and (c) greater breakup of water due to the action of the air velocity.

Table 9.—Effect of Concurrent and Countercurrent Spraying on Hydro Volute Efficiency

(Air Volume, 900 cu.ft./min.: Rotor Speed, 2,635 rev./min.: Fly Ash Loadings, 1 gr./cu.ft.)

Type Nozzle	Water Rate gal./1,000 cu.ft.	Collection Efficiency—% by weight: Concurrent Spraying	Countercurrent Spraying
None	0	40.9	40.9
Low Pressure	0.9	88.5	93.4
Low Pressure	1.9	90.4	95.9
High Pressure	2.2	97.9	99.1
Low Pressure	3.7	95.5	97.6
Low Pressure	5.6	96.8	98.4

Table 10.—Efficiency of Hydro Volute Scrubber for Various Aerosols

(water rate, 5 gal./min.: rotor speed, 2,635 rev./min.: dust loadings approximately 1 gr./cu.ft.*

		Efficiency—per cent by weight				
Air Flow Rate (cu.ft./min.)		650		900		1050
Aerosol	Nozzle	con.	counter.	con.	counter.	concurrent
Fly Ash	Low pressure	94.4	....	96.8	98.4	97.8
	High pressure	....	....	99.4	99.6	....
Vaporized	Low pressure	82.4	90.2	83.6	94.0	....
Silica	High pressure	....	....	93.8	95.2	....
Micronized	Low pressure	66.7	77.1	72.6	77.1	72.6
Talc	High pressure	....	....	95.0	95.4	....
Copper Sulfate Microspheres	Low pressure	....	....	....	....	....
					81.1	

* Loading of copper sulfate microspheres was 4.2×10^{-5} gr./cu.ft.

Table 11.—Efficiency of Droplet Eliminator Section of Hydro Volute Scrubber

Water Flow Rate gal./1,000 cu.ft.	Efficiency for 1 gr./cu.ft. Concurrent Spraying: To Eliminator	Overall	Fly Ash % by Weight Countercurrent Spraying: To Eliminator	Overall
A. Low Pressure Sprays (Figure 3b)				
(1) 900 cu.ft./min., 2,635 rev./min.				
0.9	86.4	88.5	89.8	93.4
1.9	88.2	90.4	91.6	95.9
3.7	93.9	95.5	95.9	97.6
5.6	95.6	96.8	....	....
5.6	93.8*	95.8*	....	....
(2) 650 cu.ft./min., 2,175 rev./min.				
5.6	93.1	93.1	....	....
(3) 400 cu.ft./min., 2,175 rev./min.				
...	78.2	81.3	....	....
B. High Pressure Sprays (Figure 3c)				
(1) 500 cu.ft./min., 2,635 rev./min.				
2.3	....	....	98.1	99.1
5.1	98.4	99.6	97.0	99.4

* Loading = 0.6 gr./cu.ft.

Table 12.—Water Carry-over and Air Humidification Efficiency in the Hydro Volute Scrubber *

Type Nozzle	Nozzle Position	Water Rate gal./1,000 cu.ft.	Water Collected gal./1,000 cu.ft.	Relative Humidity of Air: Entering	Leaving
Low Pressure	Concurrent	5.5	0.0025	38	90
	Countercurrent	5.5	0.01	44	98
High Pressure	Countercurrent	6.5	0.01	26	100

* Air rate 900 cu.ft./min.; impeller speed 2,635 rev./min.

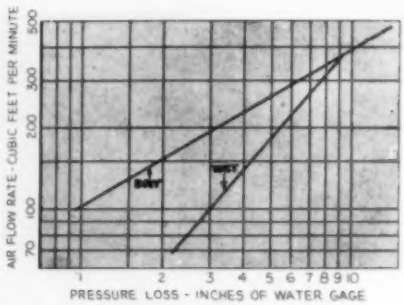


Fig. 11. Resistance of cyclone scrubber.

6. Efficiency of the Hydro Volute Scrubber for Various Dusts.

Table 10 lists the results of high- and low-pressure spray operation, at various air flows for four different test aerosols. As was noted previously, efficiency increases with rise in air rate and countercurrent operation is more effective than concurrent. Efficiency increases with increase in particle size except for talc and silica with the low-pressure nozzles. Here silica appears to give higher efficiency in spite of having smaller particles. The reason for this is thought to be connected with the self-agglomerating properties of the vaporized silica. Whether the material was not thoroughly dispersed by the duct generator or whether it rapidly reagglomerated in the inlet duct was not determined, but one or both of these explanations are probably correct. It would appear that enough material remains in the form of discrete particles to become a factor at the highest collection efficiencies, because in experiments using high-pressure nozzles silica efficiency is lower than that of the talc.

The median size and size distribution of copper sulfate microspheres and of talc are nearly alike. From Table 11 it may be seen that efficiency for copper sulfate was a few percent higher than for the talc. This small difference can be accounted for by higher specific gravity and spherical shape of the microspheres, and there appears to be no reason to believe that removal efficiency is connected with the solubility of the dust.

7. Efficiency of the Droplet Eliminator Section of the Hydro Volute Scrubber

The multiple-bend zigzag eliminator plates used in the Hydro Volute scrubber downstream of the impeller scroll are only effective for the removal of large drops (greater than 100μ) and their principal advantage is low resistance. Extensive measurements of the amount of dust removed in the eliminator section (Table 11) indicates that this part of the apparatus makes a small contribution to the over-all efficiency of the unit. It is reasonable to assume that (1) if any significant num-

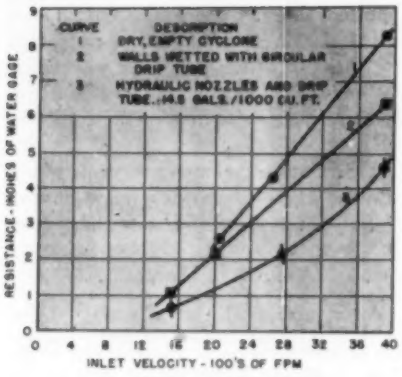

CURVE
DESCRIPTION
1 DRY, EMPTY CYCLONE
2 WALLS WETTED WITH CIRCULAR DRIP TUBE
3 HYDRAULIC NOZZLES AND DRIP TUBE...14.5 GALS./1000 CU. FT.
RESISTANCE - INCHES OF WATER GAGE
INLET VELOCITY - 100'S OF FPM

Fig. 12. Flow rate and resistance.

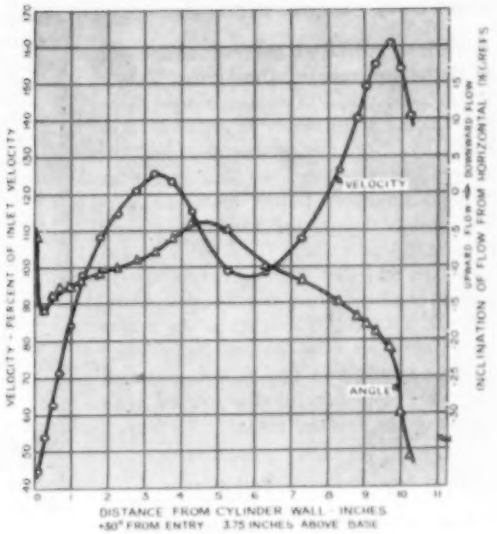

VELOCITY - PERCENT OF INLET VELOCITY
INCLINATION OF FLOW FROM HORIZONTAL - DEGREES
UPWARD FLOW
DOWNWARD FLOW
VELOCITY
ANGLE
DISTANCE FROM CYLINDER WALL - INCHES
+90° FROM ENTRY - 3.75 INCHES ABOVE BASE

Fig. 13. Air flow within scrubber cylinder.

ber of droplets, 100μ or larger, were escaping from the scroll casing to the eliminator section, there would be little likelihood of achieving efficiencies greater than 90% for materials such as fly ash, and (2) since, as a dust collector the dynamic precipitator is much superior to the multiple bend plates, there is nothing to be gained by following one dust collector by a second of far less efficiency.

Measurements were made of the amount of water collected by the zigzag plates, when the scrubber was operated with the eliminator wash-down sprays turned off by permitting run-off from the plates to drip into a graduated container for a number of hours. (The function of the sprays in the eliminator section is to wash the bent plates clean and keep them from becoming fouled with dust accumulations). Results of these measurements are shown in Table 12, along with measurements of air humidification for con- and countercurrent operation of low- and high-pressure hydraulic sprays.

Water carry-over and humidification efficiency are both much less with concurrent than with countercurrent spraying (which is indicative of the much greater contact between spray and air obtainable with countercurrent spraying) as well as demonstrating the production of more droplets small enough to reach the eliminator plates. Although the data are not shown in Table 12, it was found that the relative humidity of the effluent air was not changed by the presence or absence of the eliminator sprays. On the basis of these tests, it is believed that the eliminator section can be omitted without adversely affecting collector performance.

B. POWER REQUIREMENTS

a. Cyclone Scrubber

The power required to move air through this scrubber is dependent on collector resistance. The relation between flow rate and resistance, (dry and wet) for a cyclone scrubber using three high-pressure hydraulic nozzles is shown in Figure 11. Because of the difficulty of varying the water rate with changes in air flow, the water rate was held constant at 1.96 gal./min. for the wet runs. The resistance curves of Figure 11 show that over the range tested wet resistance is greater than dry, but that as flow rate increases this difference diminishes. If the data were extended, the two curves would probably coincide (as shown by dotted line). The explanation for this is that as the air flow increases, the relative amount of water being sprayed decreases until the power required to reverse the direction of the water droplets and to accelerate them to the velocity of the air stream becomes negligible in relation to the over-all resistance of the cyclone due to air flow alone.

For example, at an entry velocity of 3,500 ft./min. power consumption of the scrubber is 0.34 hp. or 1.1 hp./1,000 cu.ft./min. (This does not take into account the additional power required for pumping the spray water). This is a high energy requirement for this type of air cleaner, but it should be understood that the experimental collector was not proportioned for low resistance, but was constructed to demonstrate factors of importance in the design of wet dust collecting devices. The factors which affect cyclone resistance have been investigated by First (*21*) and through application of this information a cyclone scrubber can be designed which will have much lower power requirements without sacrifice of collection efficiency. The resistance (Figure 11) includes the pressure loss due to the straightening section present in the exit duct to facilitate sampling, but which would normally not be included in commercial applications of this device. Measurements indicate that this straightening section accounts for not more than 5% of the over-all collector loss.

It was noted above that the presence of nozzles near the entry of the cyclone altered the efficiency characteristics of the collector because the nozzles appear to have an effect similar to an entry vane. First (*21*) has shown that entry vanes tend to reduce the velocity of the gases throughout the cyclone producing decreased resistance and efficiency.

Additional resistance measurements were made of (1) the empty cyclone, (2) the cyclone containing the tubing necessary to produce wet walls, and (3) the cyclone containing the tubing for producing the wet walls plus three $\frac{3}{16}$-in. orifice, tangential, hydraulic nozzles spraying across the entry at the rate of 14.5 gal./1,000 cu.ft. of air, as shown in Figure 1. The results are shown in Figure 12, and it may be seen that the empty, dry cyclone has the highest resistance. (In Figure 11 dry resistance was measured with the nozzles in place and therefore it was lower than wet resistance). This again illustrates the observation that the addition of sprays or other equipment near the entry, or outer wall, of the cyclone lowers gas velocity and reduces resistance.

b. Hydro Volute Scrubber

Measurements of the wattage input to the motor running the Hydro Volute rotor were made to measure power requirements at a number of air and water rates. As these measurements reflect the power characteristics of the motor as well as unknown power losses in belting and bearings, the results are only of qualitative value. They indicate, for example, (1) that countercurrent spraying consumes more energy than concurrent spraying, (2) that as the water rate increases, the power input rises in proportion, and (3) that at constant rotor speed power input increased with increase in air flow rate.

c. Power Requirements of Spray Nozzles

The power required to atomize the scrubbing liquid may be almost completely or wholely provided by the air blower (as is the case for devices such as the venturi scrubber and the Type N Rotoclone), but more commonly droplet formation is accomplished by spray nozzles. With high nozzle pressures this operation may account for a substantial fraction of total power requirements. For pneumatic atomizing nozzles the power needed to deliver air at the required pressure must be added to that for pumping water. For example, the 400 lb./sq.in. hydraulic nozzles used in this study require a theoretical input of 0.46 hp. when spraying at the rate of 1.96 gal./min. (equivalent to 6 gal./min./1,000 cu.ft. of air). This amounts to approximately 0.55 hp. if an overall efficiency is assumed of 85% for a reciprocating pump and a piping loss of a few feet of water.

The 3/16 in. orifice diameter low-pressure tangential nozzles were operated during one set of experiments at the rate of 16.8 gal./1,000 cu.ft. of air and a nozzle pressure of 33 lb./sq.in. The theoretical horsepower requirement was 0.083, and with the assumption of a centrifugal pump efficiency of 65% and a piping loss of a few feet of water, actual power requirements were approximately 0.11 hp.

As a third example, one can consider the 25 lb./sq.in. pneumatic nozzles which consumed 0.08 gal./min. of water and 1.5 cu.ft./min. of standard air. In one experiment three of these nozzles were used, requiring 0.055 hp. for pumping the water (65% efficiency for centrifugal pump) and 0.58 hp. for compressing the air (85% efficiency assumed for a piston-type compressor) to make a total requirement of approximately 0.65 hp., including a reasonable piping loss.

From these examples it is seen that the use of compressed air nozzles is relatively costly. Experimental work has indicated that they are ineffective because the drop size is too small. The coarse, low-energy-input, tangential, hydraulic nozzles were less effective than the high-pressure, hydraulic nozzles although the deficiency of the low-pressure nozzles in the Hydro Volute scrubber did not appear to be so great as the difference in their energy requirements (i.e., a ratio of 5 to 1).

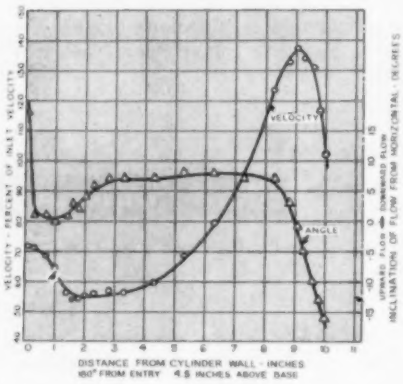


Fig. 14. Air flow pattern within scrubber cylinder.

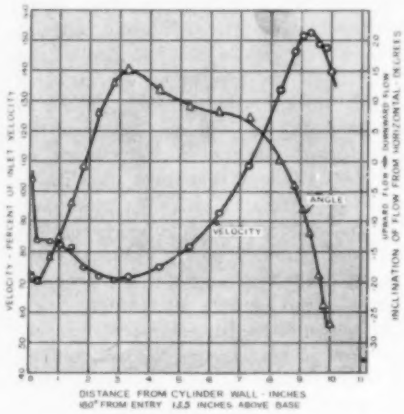


Fig. 15. Air flow pattern within scrubber cylinder.

C. AIR FLOW PATTERN AND DUST DISTRIBUTION IN CYCLONE SCRUBBER

1. Air Flow Pattern. Flow distribution was determined with an airfoil pitometer (*22*) which simultaneously measures velocity, static pressure, and direction of air flow at a point in the stream. As the name of the instrument suggests, it consists of a symmetrical airfoil section 0.25 in. in chord and 0.20 in. in span. Pressure taps are located in the center of leading and trailing edges for measurement of velocity and static pressures, and two direction indicating taps are located on opposite ends of the span. One leg of a 1:10 inclined manometer is connected to each direction tap and when the differential pressure is zero the pitometer head is facing in the direction of flow.

Pitometer traverses were made along selected radii at various levels in the cylindrical section of the scrubber and in the cone. Results of these measurements are shown in Figures 13 to 17.

A traverse made on a radius at the same level as the entry duct and 30° from the end of the entry in the direction of air flow shows the nature of the flow in the vicinity of the inlet (Figure 13). The flow is upward everywhere along the radius. The velocity at the wall is only 44% of the average inlet velocity. It reaches a peak of 125% of inlet velocity at a point 3.5 in. from the wall and then decreases to 96% of the inlet velocity at a point 6 in. from the wall. The flow in this portion of the scrubber is slightly upward. At 6 in. from the wall the flow increases rapidly in velocity and at the same time becomes steeper upward. At a point 9.7 in. from the wall the velocity reaches a maximum of 160% of the inlet velocity, and flow direction is upward at 22°. This point represents the peak flow in the inner spiral of the collector. This inner vortex has roughly the same diameter as the exit duct of the collector. From the point of peak velocity inward, the velocity falls off rapidly and the flow becomes more sharply upward. Because of limitations in the physical dimensions of the pitometer, it was not possible to make measurements any closer to the center of the scrubber.

One would expect the velocity near the inlet of the scrubber to be rather uniform. Two possible explanations can be advanced for such deviation. First the cyclone inlet is round; the relatively small amount of air entering the scrubber near the wall probably expands vertically decreasing in velocity. Second the peak velocity in the inlet air stream occurs 3.5 in. from the wall, although it would be expected that the peak velocity would occur at 2 in. or less from the wall as the inlet duct is 4 in. in diameter. In the construction of the scrubber, however, the inlet duct was not welded to the body of the scrubber exactly tangentially and the duct actually points slightly inward and upward. This explanation probably accounts for the flow pattern which occurs near the inlet.

Figures 14 through 17 show the flow pattern within the scrubber at other points chosen 180° around the body of the scrubber from the entry duct. These traverses indicate a great degree of similarity and demonstrate that the velocities within the scrubber are comparable at points not greatly influenced by the inlet air stream. Velocity within the cylinder is well below the entry velocity at all points within about 7 in. from the wall. Air flow is slowly downward through most of this region. Air in the outer part of the cylinder is forced inward when it reaches the

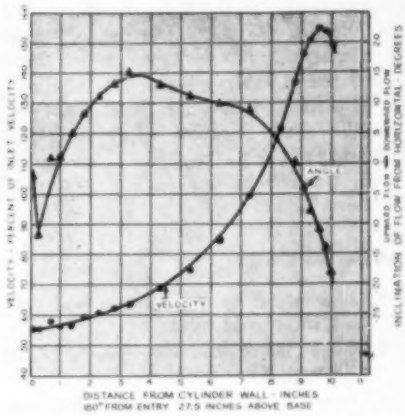

VELOCITY - PERCENT OF INLET VELOCITY
INCLINATION OF FLOW FROM HORIZONTAL - DEGREES
UPWARD FLOW + DOWNWARD FLOW -
ANGLE
VELOCITY
DISTANCE FROM CYLINDER WALL - INCHES
180° FROM ENTRY 27.5 INCHES ABOVE BASE

Fig. 16. Air flow pattern within scrubber cylinder.

cyclone cone and in this manner enters the outlet spiral.

Apparently, when the cyclone inlet is located at the bottom of the cylinder, most of the entering air flow is turned downward and enters the cone without ever rising in the cylinder. The inner spiral, on the other hand, loses air to the outer spiral during the rise through the cylinder. An examination of the position of the peak velocity in the inner spiral shows that this position shifts inward as the spiral moves upward. At the same time the peak velocity does not change significantly. The air which leaves the inner spiral in the cylinder of the scrubber moves slowly downward and eventually reaches the cone where it re-enters the inner spiral. Because of the small diameter of this outlet spiral and because of the vortical flow, very high velocities are encountered. Peak velocity averages about 155% of inlet velocity and occurs at a point about 9 in. from the wall. The direction of flow is slightly upward at this point. From the point of peak velocity, the velocity falls off very rapidly towards the center of the outlet spiral. The flow also turns sharply upwards near the center of the spiral.

The flow patterns shown by these figures are in general agreement with those measured by First, (*21*) although the cyclones in which he measured flow patterns were somewhat different in design. A typical double-spiral type of flow exists consisting of a slower downward-moving outside spiral and a rapidly upward-moving inner spiral. The viscous and turbulent forces acting at the interfaces of these layers of air, which are moving at different velocities and in different directions, contribute to the energy loss which is encountered in the cyclone.

Since the angle at which the outer spiral moves downward is seldom more than 10°, the air stream makes several revolutions within the scrubber before being turned into the inner spiral. The greater the number of turns of the air stream which occur in the scrubber, the greater the chance for collection as centrifugal forces and impaction on droplets have a greater length of time to exert their action. Air in the inner spiral also makes several turns within the collector as it moves upwards towards the outlet. Since a high velocity exists in the inner spiral which is relatively small in diameter, a rather large centrifugal force will act on any particles traveling in the inner spiral. This passes dust particles outward away from the center of the collector. The high velocity and small radius of this inner spiral probably contribute greatly to the collection efficiency of the scrubber.

2. Loading Variation Within the Scrubber. Once the flow characteristics within the scrubber were determined, it was possible to determine the manner in which dust was distributed within the scrubber. From this information the nature of the action which was taking place could be deduced and information concerning the differences between wet and dry operation was obtained.

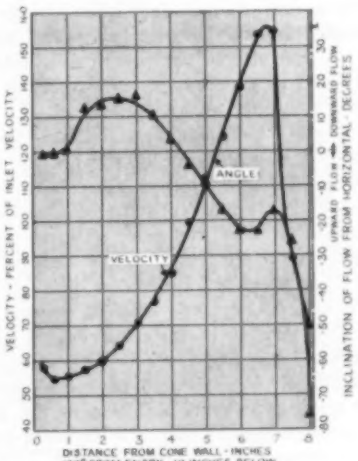

VELOCITY - PERCENT OF INLET VELOCITY
INCLINATION OF FLOW FROM HORIZONTAL - DEGREES
UPWARD FLOW + DOWNWARD FLOW -
ANGLE
VELOCITY
DISTANCE FROM CONE WALL - INCHES
180° FROM ENTRY - 10 INCHES BELOW CYLINDER BASE

Fig. 17. Air flow pattern within scrubber cone.

Flow patterns were measured on the dry cyclone with the nozzles in place. It is assumed that the patterns do not change significantly when the nozzles are being operated. Although the sprays may have some effect on the flow near the entry, this effect is probably smoothed out quickly within the scrubber.

The loading variation was measured along three radii located 180° around the body of the scrubber from the inlet duct. Sampling velocities and the direction in which the sampling probe was pointed were determined from the flow patterns.

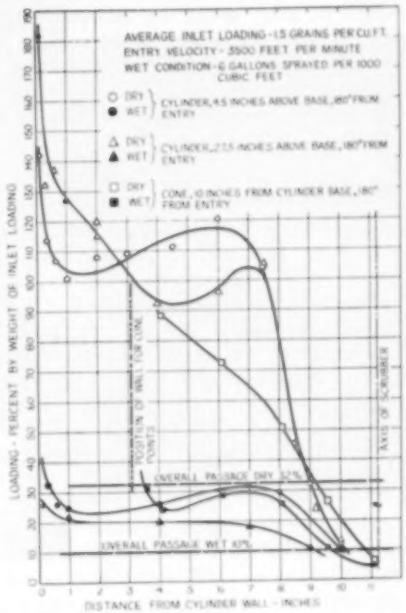

AVERAGE INLET LOADING - 1.5 GRAINS PER CU.FT.
ENTRY VELOCITY - 3500 FEET PER MINUTE
WET CONDITION - 6 GALLONS SPRAYED PER 1000 CUBIC FEET
DRY
WET
CYLINDER, 4.5 INCHES ABOVE BASE, 180° FROM ENTRY
CYLINDER, 27.5 INCHES ABOVE BASE, 180° FROM ENTRY
CONE, 10 INCHES FROM CYLINDER BASE, 180° FROM ENTRY
LOADING - PERCENT BY WEIGHT OF INLET LOADING
LOCATION OF WALL LOADING POINTS
AXIS OF SCRUBBER
OVERALL PASSAGE DRY 67%
OVERALL PASSAGE WET 83%
DISTANCE FROM CYLINDER WALL - INCHES

Fig. 18. Loading variation within the scrubber.

dust collection

Loading variation was obtained both for dry conditions and with 6 gal. of water/1,000 cu.ft. of air being sprayed.

Results of this study are plotted in Figure 18. Loadings within the scrubber are presented in per cent of the inlet loading. The over-all loading to the collector was held nearly constant for all of the points plotted.

As would be expected, the loading at the wall of the collector is considerably higher than the inlet loading. The loading decreases away from the wall but in the case of the traverses made in the cylinder of the collector, it does not fall below the inlet value. There is a slight increase in loading approaching the inlet spiral and a rapid decrease in loading within the inlet spiral. A comparison of these curves with the corresponding flow patterns shows that the downward moving air stream is heavily dust laden whereas the upward spiral is lightly laden. This suggests that most of the dust separated is deposited by the air in the cone before it enters the upward spiral. The collector is much enhanced by the small size of the inner spiral which, in turn, is due to the small size of the outlet duct.

Fig. 2. Fractionator bank for

Loadings obtained while the sprays were in operation showed the same shape as those under dry operation but were located at a much lower level. This indicates that most of the dust is captured by the droplets and removed from the air stream soon after entering the scrubber.

Discussion of Results

The tests indicate clearly that addition of water (or other suitable liquids) produces a significant increase in dust-collector performance through two distinct mechanisms, i.e., particle conditioning (whereby small particles become larger and heavier by the addition of water) and particle collection (the trapping, wetting, and flushing away of precipitated dust before it can become re-entrained in the air stream).

Experiments with the wetted wall cyclone scrubber and with some types of spray nozzles show that the mere addition of water to a dry collector does not automatically guarantee a significant improvement in collection efficiency. These experiments indicate that optimum effectiveness for the wet process is achieved only by careful design.

The optimum amount of water is determined by pumping costs, water availability, final sludge disposal facilities, and collection efficiency. The tests show that increases in water rate (other items constant) result in improved collection efficiency on a logarithmic increment curve, because as efficiency increases through the addition of liquid, each succeeding increment of water must act on cleaner and cleaner air and on particle sizes less susceptible to the separating forces. Brandt (*2*), based on an equation proposed by Kleinschmidt, has suggested on theoretical grounds that efficiency (E) of the cyclone scrubber (due to scrubbing with water) is as follows:

$$E = 1 - e^{-1.5rW/dQ} \qquad (1)$$

where

r = scrubber radius (ft.)
W = water volume (cu.ft./min.)
d = particle diameter (ft.)
Q = air rate (cu.ft./min.)

Results with the cyclone scrubber (and the Hydro Volute) do not follow this law for efficiency and water rate because of the additional cyclonic inertial separation but show an exponential relationship does exist which may be expressed as follows:

$$E = 1 - e^{-aW^n} \qquad (2)$$

where

a = a constant to be determined experimentally
n = an exponent to be determined experimentally.

On the basis of these experimental results it is apparent that the value of n is affected by such factors as the type and location of the spray nozzles and the value of a is determined by the characteristics of the aerosol (*i.e.*, size, loading, etc.).

These experiments also show that increases in air volume result in more efficiency. This is consistent with performance data from other types of centrifugal or inertial dust collectors. The rise in efficiency over dry operation accompanying increases in air volume can be accounted for by the collection of smaller droplets containing dust particles and the greater relative motion between water droplets and dust particles under the influence of greater centrifugal force. This effect, noted in both cyclone and Hydro Volute scrubbers, is characteristic of inertial collection, whereas an increase in efficiency with a decrease in air rate would be characteristic of diffusional or electrostatic forces. This is illustrated by theoretical relationships presented by Ranz (*5*). Though Ranz's equations are of great value in defining and limiting those factors which may play a part in the impaction of particles by spray droplets, they fail to account for the subsequent deposition of the dust-laden droplets. Such relationships may be applied only with difficulty to the practical situation embracing wide ranges in size for both dust cloud and spray droplets.

These experimental studies have indicated the importance of the proper application of the sprays. For both wet collectors tested, spraying countercurrent to air flow was more effective than concurrent spraying. This reflects a greater breakup of droplets into effective sizes and more efficient impaction due to greater initial relative velocities between dust and droplet. This increase in efficiency is secured at the expense of greater pressure loss due to the energy required to stop the droplets and accelerate them to the velocity of the moving air stream.

Experiments have indicated that there is an optimum spray droplet size. Though measurements have not been made of the drop size distribution from the nozzles used in this study, it has been observed that the nozzles producing the smallest drop sizes and those producing the largest drop sizes were equally ineffective. Although, in one case, the drops were small enough to show good impaction efficiency from the standpoint of the important dust-to-droplet ratio, they almost instantaneously assumed the velocity and direction of the air stream, thereby reducing the relative velocity between dust and droplet to the vanishing point. The large droplets were too big for maximum effectiveness in impaction and, for a given volume of water and air, too few are formed. On the basis of information on the size distribution of droplets from a variety of nozzle types which have appeared in published accounts (*16, 17*), it is estimated that the mean drop size of the most effective spray nozzle is about 50 to 100μ in diam. This agrees with the conclusions of Johnstone and Roberts (*6*).

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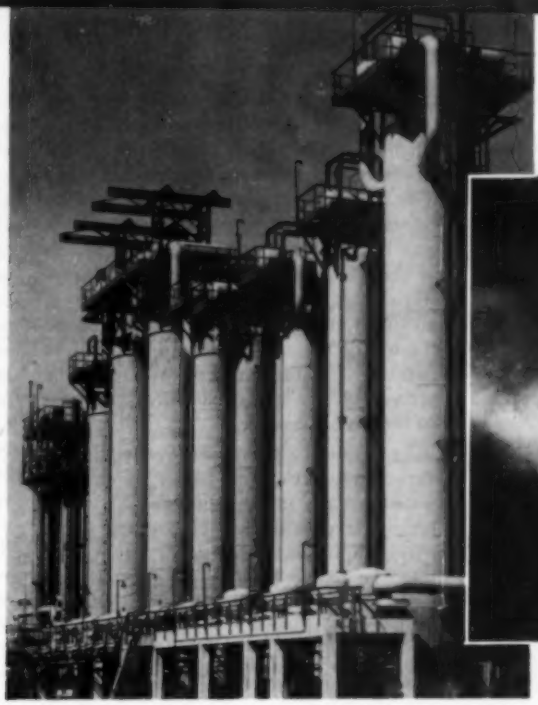

Fig. 2. Fractionator bank for finishing styrene.

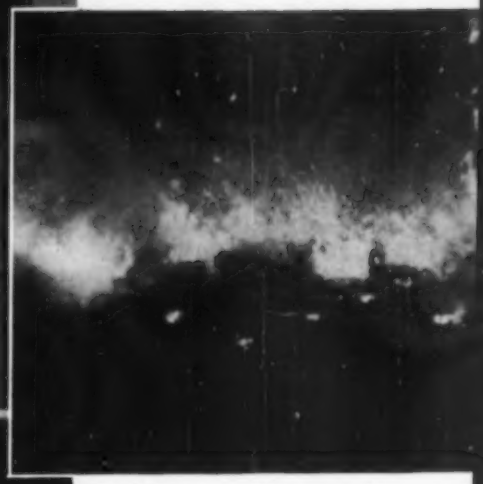

Fig. 3. Inactive bubble caps on 6th tray of original fractionating columns.

COMPENSATION FOR HYDRAULIC GRADIENT IN A LARGE FRACTIONATOR

J. A. May and Joseph C. Frank | Dow Chemical Company, Midland, Michigan

It is axiomatic that a difference in liquid head, or an hydraulic gradient, must exist to cause a liquid flow across a bubble-cap tray. Ordinarily this presents no problem when the still is small in diameter and liquid loading is moderate, but for conventionally designed large-diameter bubble-cap trays this liquid gradient results in nonuniform bubbling over the tray with reduced vapor rate in the areas of greater liquid depth. Excessive liquid gradients may prevent vapor flow from several rows of caps on the high side of a tray and, in extreme cases, may result in surging liquid flows causing unstable and erratic tower operation with serious reduction in efficiency and capacity.

The general facts have become well known during the past decade, but design engineers are still dependent on indirect data for predicting hydraulic gradients. The published literature reports measurements taken almost altogether from simulated experiments with air and water flows in test sections of bubble-cap plates. Whereas these data are of obvious importance, there are unexplained differences between the investigations so that a need exists for direct information on full-scale equipment.

An objective of this paper is therefore to present observations of tray operation including qualitative measurements of hydraulic gradient for large-diameter commercial fractionating towers. Though these estimates of hydraulic gradient are only qualitative, they have important significance as tests for the extrapolations of air-water laboratory data. Attention is also called to the direct influence of hydrostatic head variation upon the distribution of vapor on a bubble-cap tray; and a simple mechanical design which has satisfactorily compensated for hydraulic gradient is illustrated.

Problems Encountered—Styrene Fractionating Columns

In the production of styrene monomer one of the more difficult problems to solve was the separation of ethylbenzene and styrene. The two compounds boil within 9° C. of each other at atmospheric pressure. In addition, styrene will polymerize rapidly at elevated temperatures so that it is necessary to fractionate under vacuum to keep the temperature low. To accomplish this separation commercially, it was necessary to design a bubble-cap tray of high efficiency, low pressure drop, and low liquid holdup.

The tray design evolved was a bubble-cap tray with a conventional 3-in.-diam. pressed-steel bubble cap on triangular pitch with low slot submergence and a minimum liquid level on the tray. With this design, similar in detail to that shown in Figure 5, the separation requires at least seventy actual plates. To keep the bottom temperature below limits where polymerization becomes excessive, the fractionator is split into two sections of thirty-eight and thirty-two trays with complete condensation to maintain vacuum at the top of each column. Because of the vacuum operation, several columns are required in commercial production units even with 10- to 12-ft. diam. fractionators.

At the beginning of World War II, two large styrene plants were designed, constructed, and operated for the Synthetic Rubber Program under the direction of The Dow Chemical Company. A description of the process, which was developed by Dow Research and Engineering, has been given by Mitchell (*8*).

Twelve 10-ft. diam. fractionating columns were designed and installed for the ethylbenzene-styrene separation in these plants. Although they accomplish their purpose, these columns are limited in capacity by the onset of cylic disturbances when design loading is only slightly exceeded. This cyclic disturbance or surging is characterized by marked variation in pressure and fluid flows with secondary effects on operating temperature. This surging is cyclic

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although the period of the cycles is not necessarily regular and varies in the range of 3 to 15 min. After eliminating from consideration instrumentation and other plausible explanations, hydraulic gradient became suspect and was subsequently proved responsible for the peculiar behavior common to all twelve columns.

Although the loading is not so great and the subject columns are not so large as many found in petroleum refining, they are designed for vacuum service and are consequently particularly subject to the effects of liquid buildup. The magnitude of this gradient likewise is much lower than observed in some other columns, but as pointed out by Harrington, Bragg, and Rhys (5) *et al.*, the controlling factor for stable operation is not the amount of liquid buildup, but rather the ratio of liquid gradient to the cap pressure drop.

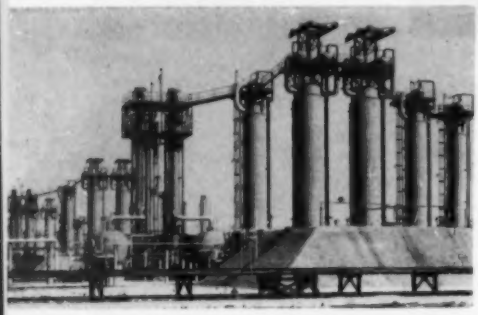

Fig. 1. General view styrene finishing facilities, Texas Division, The Dow Chemical Company.

Figure 3 is a picture taken of normal operation on the sixth tray from the tower bottom. It will be observed that four or five rows of caps are inactive on the inlet side of the tray. As the tower loading is increased, the liquid height is observed to rise on the inlet side of the tray with additional rows of caps becoming inactive. At first a vapor drift becomes discernible which soon changes to a violent horizontal wind blowing from the outlet to inlet side of the tray. Within a short time the clear liquid level has submerged the caps by several inches and practically all the vapor passes through perhaps a half-dozen rows of caps on the far side (outlet). By this time the horizontal flow of vapors has ceased and quite abruptly furious bubbling breaks out on the inlet side of the tray followed shortly by subsidence of liquid level and resumption of normal tray operation. Some 4 to 5 min. are found to elapse between periods of normal operation, and although the outlet side of the tray is not clearly visible no backtrapping of liquid through the inlet side risers of the plate above is believed to occur.

Observations were also made of tray operation on the thirty-sixth tray. The surging type of behavior was less distinct but occurred perhaps more frequently and was of shorter duration. Observations were made simultaneously with the aid of portable telephones to communicate between stations, but it was not possible to correlate the action at the different plates. On the thirty-sixth tray, inlet side liquid level was at all times at least one half to 1 in. above the top of the caps and only one half to two thirds of the tray ever seemed to be active. Heavy spray was thrown almost to the tray above.

Increased vapor velocity would be expected to result in better vapor distribution and all experimental studies on single plates have shown that for a given liquid rate a definite vapor rate must be reached before all caps become active. In a vacuum still vapor velocity will be considerably greater in the top of the column, but in the present case, at least, fewer caps are active in the top section than on the lower trays. It has been found, too, that the subject columns become more stable as the operating pressure is increased and vapor velocity is thereby decreased. Thus the anomalous behavior of the present columns must be explained by the fact that the dynamics of a single test plate are not entirely comparable to the action within a multiplate column.

For a vacuum column low tray pressure loss is desired, and cap layout and detail generally result in a relatively large hydraulic gradient as compared to average cap pressure drop. Distribution of vapor is therefore sensitive to liquid buildup. With increased vapor rate the effect of increased resistance to liquid flow is relatively greater than the increase in vapor resistance so that more caps are inactivated which causes an increased amount of vapor cross flow. This cross flow of vapor further aggravates the situation by increasing the liquid buildup by what has been described as the "Red Sea" effect. The interaction of liquid and vapor may result eventually in an operable equilibrium or the conflict may continue until liquid buildup fills the downcomers and floods the tower or else a cycle is established in which buildup reaches a break point at which the liquid-vapor flow pattern changes to re-establish normal operation.

The similarity between the construction and tray action observed in the subject columns, which is illustrated in Figure 4, and that reported by Harrington (5) for large petroleum refinery fractionating columns is striking. Trays of the present columns are supported on three 1-in. by 4-in. bars, one of which is visible at the top of Figure 3. Because of close-plate spacing (15-in.) these support bars constitute serious restrictions to vapor cross flow. As tower loading is increased, liquid buildup mounts as vapor cross flow increases. As the vapor ascends the tower, the magnitude of this effect increases, because of decreasing pressure and increasing vapor velocity, until on some particular tray the pressure drop through the tray plus the cross flow pressure drop on the tray below exceeds the clear liquid head above the cap slots on the inlet side. When this occurs, the vapor short-circuits the cross flow path and breaks through the inlet side caps with vigorous action as intial bubbling lowers the apparent liquid density by aeration. With the redistribution of vapor, the liquid level begins to subside on the initiating tray and bubbling breaks out shortly on the inlet side of the next lower tray with this chain of events continuing downward until normal operation is re-established. It is surmised that such behavior may occur concurrently, but independently in different sections of the tower and that the operation of contiguous trays is characteristic of different phases of the cycle.

The normal manner of operation prescribes tower loading somewhat under the "critical" range with the flow rates specified in Table 2 being typical. Under these conditions some four or five rows of caps on both the sixth and thirty-sixth trays were observed to be inactive though vigorous bubbling was everywhere evident otherwise and smooth operation prevailed in contrast to the surging behavior previously described. Visibility on the thirty-sixth tray was poor, but it appeared that the inlet side liquid level was nearly cap height. The inlet weir was visible on the sixth tray with the crest over the weir appearing to be about half an inch. Liquid level on the inlet side on this tray was half an inch or so below the top of the caps and was about even with the weir crest.

Hydraulic Gradient Compensation

Measures which have been suggested for coping with hydraulic gradient include increasing cap pressure drop to equalize vapor distribution over the tray by decreasing the tower operating pressure, by installing chokes in existing chimneys, by employing high-pressure drop caps, or by blanking caps according to some prescribed pattern. The hydraulic gradient itself may be decreased by increasing cap spacing, by raising the outlet weir, or by increasing the mini-

Table 1.—Tray Design Data

Plate No. (from bottom)	14
Operating pressure, mm.	108
Operating temperature, ° C.	78
Liquid composition, wt. %	
Ethylbenzene	72
Styrene	28
Liquid density, lb./gal.	6.89
Liquid flow rate, lb./hr.	20,500
Vapor flow rate, lb./hr.	25,000
Height of weir crest, in.	0.333
Hydraulic gradient calculated, in.	0.67

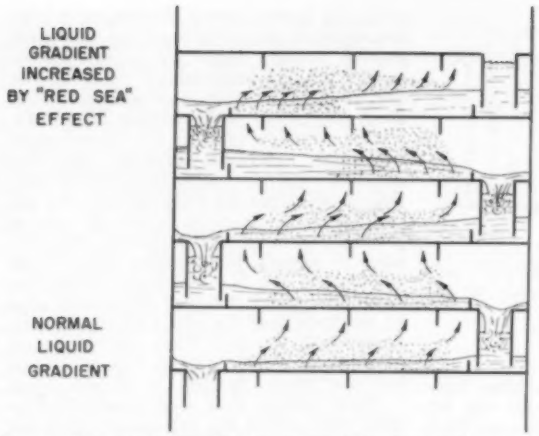

Fig. 4. Tray operation showing vapor cross flow and "Red Sea" effect on liquid buildup.

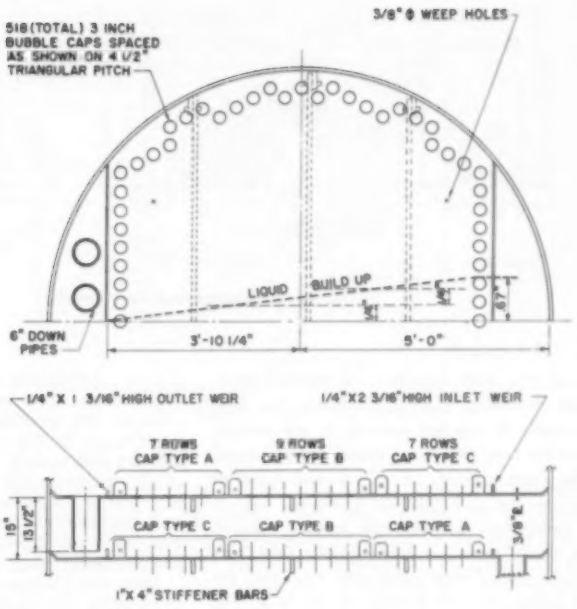
518 (TOTAL) 3 INCH BUBBLE CAPS SPACED AS SHOWN ON 4 1/2" TRIANGULAR PITCH
3/8" ø WEEP HOLES
LIQUID BUILD UP
6" DOWN PIPES
3'-10 1/4"
5'-0"
1/4" X 1 3/16" HIGH OUTLET WEIR
1/4" X 2 3/16" HIGH INLET WEIR
7 ROWS CAP TYPE A
9 ROWS CAP TYPE B
7 ROWS CAP TYPE C
CAP TYPE C
CAP TYPE B
CAP TYPE A
1" X 4" STIFFENER BARS

Fig. 5. Tray details for 10-ft. diam. fractionating column.

mum seal depth. Also decreasing the liquid flow rate or the number of rows of caps would obviously lessen the liquid buildup.

For the particular columns under discussion the liquid flow per foot of plate width is already low. Furthermore, the operating pressure can not be significantly reduced and experience has shown that greater stability results from raising the operating pressure. Orienting the tray support beams parallel to the liquid flow and increasing the plate spacing would minimize the "Red Sea" effect associated with vapor cross flow, but these measures are not altogether desirable and are obviated by proper vapor distribution. The other methods mentioned in the preceding paragraph for minimizing hydraulic gradient and improving vapor distribution also have disadvantages since they violate one or more of the design requirements previously expressed.

A further possibility would be to shorten the liquid path by a cascade tray arrangement with the use of one or more steps with intermediate weirs at each step. This type of tray design becomes complicated structurally in a large diameter column and it increases the column height. A split flow (two pass) tray was also considered and rejected. This type of tray design has two disadvantages (1) the effective cross-sectional area is decreased by about 10% because of the area taken up by the section between the weirs at the center of the column, and (2) the advantage of cross-flow enrichment is greatly diminished.

The preferred means for compensating for hydraulic gradient thus appeared to be to establish a uniform liquid seal above the cap slots. This might be done by sloping the complete tray toward the outlet weir. As an alternate, the comparatively simple procedure of varying the height of the slots above a level tray was chosen since it was not a major change from the tray design in use and it retained most of the operational flexibility. Figure 5 shows a typical tray layout in which staged bubble caps were used. For simplicity of cap design and assembly the caps were divided into three groups of caps of the same slot height.

Table 2.—Operating Conditions During Tower Observation

	Old	New
Feed rate,* lb./hr.	8,000	8,000
Reflux, lb./hr.	24,000	24,000
Product, lb./hr.	4,800	4,800
Bottoms, lb./hr.	3,200	3,200
Top temp., ° C.	58	58
Bottom temp., ° C.	91	87.5
Pressure, mm.		
Top	56	56
18th tray	107	95
13th tray	117	105
7th tray		117
2nd tray		127
Bottom	148	132

* Bubble-point feed introduced on 13th tray from bottom of 38-plate column.

The first installation in the Dow Chemical Company where staged bubble caps were used was in the styrene plant at Midland, Michigan. The columns here were designed in 1945 when only the data by Good, Hutchinson, and Rousseau (*4*) were available. The design was effected by a comparison of the operation of the styrene columns with the data taken from experimental runs made by Good, *et al.*, on a test tray. It was necessary to make several important assumptions, but it was estimated that the maximum hydraulic gradient in these columns was between 1.0 and 1.25 in. The two new columns were designed conservatively with the slots at the tray inlet 5/8 in. above those at the outlet. These columns performed well at as much as 35% greater loading than columns having trays without compensation.

The second installation of two columns was at Dow's Texas Division styrene plant, which was formerly Plancor 930. These columns were designed in 1950, at which time there were more data available, including the Davies correlation (*1*), Kemp and Pyle (*6*), and Klein (*7*). The rest of the discussion of calculations and observations concerns the design and operation of this second installation.

For computing hydraulic gradient to determine cap staging for the two new Texas Division columns, the Davies equation was used at the minimum anticipated operating rate. Furthermore, the gradient was computed for the first tray above the feed at which point liquid buildup is a minimum. This approach was pursued with the intention that these stills would be entirely effective at low rates and improved at higher rates without risking overcompensation. The performance of the new towers has been gratifying with smooth operation prevailing throughout a wide operating range limited only by entrainment and pressure drop at a capacity of more than 150% that of the original columns.

Observation ports were installed on the new thirty-eight tray columns above the sixth, eleventh, and thirty-fourth trays numbering from the bottom. Under the conditions reported in Table 2, bubbling was vigorous on the inlet

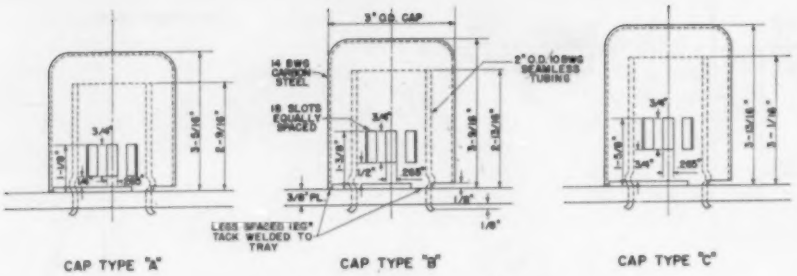

Fig. 6. Bubble-cap and riser details.

side of the sixth tray with a massive spray height extending 1 to 2 in. above the inlet side caps. It was not possible to see entirely across the tray, but vapor distribution appeared to be quite uniform. A picture was taken of action on the sixth tray but it attested only to the activity on the inlet side so that inclusion here would serve no purpose. The inlet weir and downcomer were visible with head over the weir appearing to be between ¼ and ½ in. The unaerated liquid height appeared to be about 1½ in. below the top of the caps and was definitely below the weir crest.

The sight glasses above the eleventh tray are on the outlet side of the tray permitting the outlet weir and downcomer to be seen. The segment behind the weir was completely filled at the ends with the liquid level dropping to a minimum at the middle. Although the last row of caps jetted liquid over the weir, as was also the case at the inlet weir on the sixth tray, there appeared to be no foam behind the outlet weir. The weir crest again appeared to be between ¼ and ½ in. with the liquid level on the tray being about 1½ in. below the top of the caps. Vapor distribution appeared to be good and no suggestion of vapor cross flow was evident.

On the thirty-fourth tray as on the sixth tray the sight glasses are on the inlet side of the tray so that the inlet weir and downcomer may be seen. The weir crest was between ¼ and ½ in. from which the liquid level dropped to an unaerated height about 1¼ in. below the top of the caps. Massive spray extended between 3 and 5 in. above the caps and vapor distribution appeared to be good with no evidence of cross flow.

Calculation of Hydraulic Gradient

For staging the caps in the two new columns the hydraulic gradient on the fourteenth tray (first tray above feed) was computed by the Davies method (*1*) for the conditions set forth in Table 1. Figure 6 presents bubble-cap and riser details and Figure 5 shows the tray layout superimposed upon which is plotted liquid buildup, which was assumed to be linear.

Consistent with the interpretation of orifice-type head losses the row length, though not specifically defined by Davies, has been considered for this application to include the minimum distance from the last cap in each row to the tower wall. In calculating the crest over the outlet weir, approach velocity and tower wall weir restrictions were taken into account according to Edmister's recommendations (*2*).

Although tray operation could not be seen on the fourteenth tray, observations were made at the sixth tray for both the old and new towers. Whereas the operating conditions indicated in Table 3, which take into account plate weepage, induced reflux, and unequal overflow differ from the design basis, the calculated and observed gradients at these conditions compare favorably.

Since the Davies correlation (*1*) is based to a large extent upon the data of Good, Hutchinson, and Rousseau (*4*), it was of interest to apply the findings of the latter investigators directly to this problem. Kemp and Pyle (*6*) also investigated hydraulic gradient and more recently Klein (*7*) conducted an extensive research into hydraulic gradient determination. In order to satisfy the possibility that the agreement between Davies and observed gradients was not merely happenstance but would have been obtained by other methods, the various methods were tested at the conditions indicated in Table 3.

Neither the data of Good, et al., (*4*) nor that of Kemp and Pyle (*6*) were directly applicable to the conditions of the present problem and in particular the cap design and spacing differed from that employed in the subject columns. Considerable extrapolation and interpolation were necessary even to predict gradients assuming test tray cap layouts. In order to estimate the hydraulic gradient for 4½-in. cap spacing from the gradients computed for 4¼-in. spacing by Good and for 4¾-in. spacing by Kemp and Pyle, it was necessary to multiply these gradients by the ratio of the gradients calculated by the Davies method (*1*) for 4½-in. cap spacing and the spacing in question. This manipulation, of course, decreases the accuracy of the estimate, but even so, reasonable results were obtained.

The gradient determined by Good, *et al.*, when calculated by the recommendations of the authors was somewhat greater than that determined by Davies or by Kemp and Pyle. Good indicated a correction for tray liquid density and also recommended comparing different tray arrangements at equal average seal depths. Kemp and Pyle found hydraulic gradient to be independent of liquid density and they stipulated that computations should be made at the same outlet side pool depths. Incorporating the Kemp and Pyle recommendations into the Good method resulted in closer agreement between the calculated values for hydraulic gradient.

The computation of hydraulic gradient developed by Klein (*7*) and ably delineated by Gilliland (*9*) was also applied to the present problem. Whereas Davies based his correlation upon orifice-type calculations, Klein took exception to this interpretation proposing instead that a Fanning-type friction equation should be used. Klein's work showed a high degree of correlation in general but failed miserably for the application at hand, the calculated gradient being about one tenth of the correct magnitude. Further consideration of his experimental data and hypothesis revealed that the difficulty was due to differences in tray details. Whereas the installed caps are tall and the liquid level is below the top of the caps, as stipulated by Davies, the caps used in Klein's investigation were short and wide so that flow was largely above the caps. Klein neglected both the surface area of the caps and the effect of cap volume upon liquid velocity. Since his correlation is based upon surface drag, departure from test tray details can lead to serious error.

When Klein's data were recalculated to take into account the cap surface area and contribution of cap volume to flow rate, essentially straight lines were found for Klein's modified friction factor for each weir height. Klein also found a dependence of his friction factor upon weir height, but he was able to draw the separate curves together by use of a dimensionless factor involving slot height and outlet hydrostatic head. He did not account for vapor velocity, which appears to have negligible effect at high weir settings; but for the recalculated 1-in. weir curve there was a considerable scattering of points apparently due to vapor velocity.

The empirical relation found by Klein to correlate the various weir settings was not effective for the recalculated friction factors, so the individual weir curves shown in Figure 7 were used to interpolate for the installed weir height.

For calculating the mean hydraulic radius in the present application the ratio of flow volume to total wetted surface area was used. Flow volume refers here to the free space between the weirs assuming an average foam height of twice the hydro-

Table 3.—Sixth Tray Operating Conditions and Hydraulic Gradient Comparison

Operating pressure, mm.	127
Operating temperature, ° C.	85
Liquid composition, wt. %	
Ethylbenzene	42
Styrene	58
Liquid density, lb./gal.	6.94
Liquid flow rate, lb./hr.	31,400
Vapor flow rate, lb./hr.	29,200
Height of weir crest, in.	0.439
Hydraulic gradient, in. tray liquid:	
Observed gradient estimate old tower	1.00
Observed gradient estimate new tower	0.70
Calculated Gradient	
Davies	0.80
Good, *et al.*	1.10 [1]
Good, *et al.*	0.96 [2]
Good, *et al.*	0.90 [3]
Kemp and Pyle	0.69
Klein	0.07 [1]
Klein	0.70 [4]

[1] Calculated according to authors' recommendations.
[2] Hydraulic gradient assumed to be independent of liquid density.
[3] Same as [2] but calculated at equal outlet pool depths.
[4] Calculated with use of revised friction factor relationship.

static head at the outlet weir, as recommended by Klein. Wetted surface includes all surface areas contributing to flow resistance excluding, however, the weir surfaces. In computing wetted surface for the installed caps the top area was not included, as flow was essentially between the caps. This condition may also have prevailed for Klein's 1-in. weir, but no exception was made for this case in the revised treatment of Klein's data, and accordingly some error may have been introduced.

With this modification of Klein's work the gradient was computed as 0.70 in. in agreement with observed and other calculated values for hydraulic gradient. Since the actual liquid viscosity of 0.00024 lb./(ft.)(sec.) was used in these computations, the use of actual viscosity appears to be confirmed for all liquids rather than the use of 0.00067 lb./(ft.)(sec.), as a minimum value of viscosity as tentatively recommended by Gilliland.

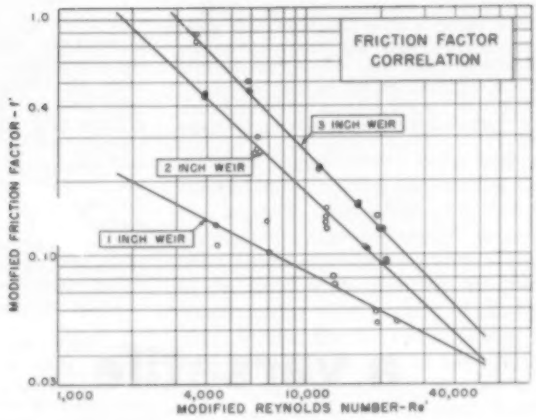

Fig. 7. Modified Klein friction factor correlation.

Criterion for Bubble-Cap Staging

Various correlations for predicting hydraulic gradient have been developed largely if not wholly from studies on single-tray sections and, as in all empirical relationships, reliability and limitations are best determined by full-scale application. In this regard only one other case is known to be published (*3*).

In view of the different tray layouts, and the approximations and assumptions involved in applying the various methods of computation, the agreement between the observed and the variously calculated values for the hydraulic gradient is remarkable. The gradient compensation in this case would thus have been essentially the same regardless of the interpretation or particular correlation employed.

Although the use of hydraulic gradient for cap staging appears to have been quite satisfactory in the present instance, doubt is raised whether the hydraulic gradient is the proper criterion. Klein (*7*) has shown that the difference in hydrostatic head across the bubbling zone on test plate was much smaller than the hydraulic gradient. Gilliland (*9*) has theorized further that the pressure drop for a plate with caps just becoming inactive should equal approximately twice the pressure drop for the same plate with the same vapor load uniformly distributed. Although a definite improvement in pressure drop was obtained for the staged-cap towers, the improvement was not so good as might have been expected. This suggests that vapor distribution is better than would be suspected from the magnitude of the hydraulic gradient.

Whereas the hydraulic gradient is a measure of the resistance to liquid flow and is amenable to calculation, the distribution of vapor is fixed by the hydrostatic head at the cap slots, and it is likely that the use of hydraulic gradient for staging caps will lead to overcompensation. Klein found that the center of gravity of the aerated liquid varies progressively across the tray. Connecting the midpoints of the clear liquid zones on either side of the bubbling section, the center of gravity curve has a slope of half the hydraulic gradient. Unfortunately, however, this curve also appears to have no direct relation to the hydrostatic gradient. Of the various cases studied by Klein, the hydrostatic gradient varied from practically nothing to no greater than one-half the hydraulic gradient depending upon vapor and liquid dates, the outlet weir height, and the number of rows of caps.

In order to predict hydrostatic gradients for uniform vapor distribution and to determine the proper staging of caps, a rather elaborate experimental tray is indicated. Positive control of air to each row of caps should be provided by separate ducts and each row of caps and risers should be adjustable as to height so that hydrostatic head for each row can be fixed at a constant value. Computations for gradient should account for the various row heights and the effect of underflow for the raised caps if appreciable. However, since the proper criterion for cap staging is not presently evident and since some overcompensation can be tolerated, it is tentatively suggested that one-half the hydraulic gradient be used for this purpose. Such compensation would ordinarily not be great but would effect much improved tower performance by a simple means.

Conclusions

In the design and operation of large diameter bubble-cap columns hydraulic gradient is an important consideration.

Vacuum stills are particularly vulnerable to the effects of liquid buildup even when the loading is moderate. Though a number of things can be done to improve a given situation, if the characteristic of low tray pressure drop is to be retained the hydraulic gradient must be accepted and steps taken to counter the adverse effects. The most serious effects of hydraulic gradient all center about the maldistribution of vapor over the tray. Correcting vapor distribution automatically takes care of the usual difficulties and ordinarily this can be accomplished simply by raising the caps on the inlet side of the tray.

For the case at hand caps were staged to approximate the hydraulic gradient under conservative operating rates. Though completely satisfactory results were obtained, this procedure will lead to overcompensation for a particular operating rate since vapor distribution depends upon the hydrostatic gradient in the bubbling section rather than upon the hydraulic gradient. From information presently available the hydrostatic gradient is generally no greater than half the hydraulic gradient and in some cases is much less. Probably considerable overcompensation may be tolerated, so until additional information is available, it is recommended that cap staging conform to one-half the hydraulic gradient. For calculating the latter the several published methods modified as indicated herein gave satisfactory results for what might be considered a check point in the realm of full scale operation.

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Presented at A.I.Ch.E. meeting, Springfield, Massachusetts.

a versatile MULTISTAGE EXTRACTION UNIT

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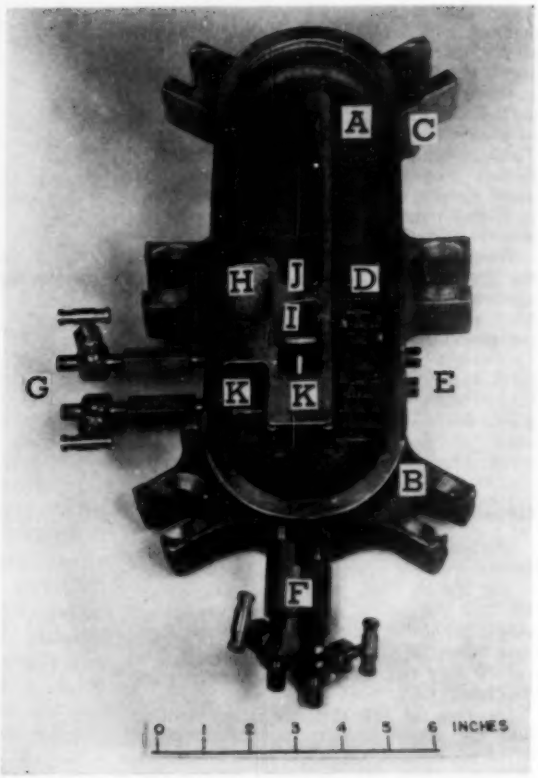


Fig. 1. End angle view of two-stage extraction unit for twenty-stage extractor. A) top extraction stage (lower stage in bottom half of unit is not visible); B) lugs for clamping bolts; C) dowel holes for aligning unit; D) double-perforated-plate mixer in place; E) ¼-inch pipe plugs (when removed, mixer-plate set screws are accessible from outside the unit); F) light-phase sample taps (top-stage sample line is visible); G) heavy-phase sample taps; H) heavy-phase downcomer from stage above the one shown; I) light-phase riser from stage below the one shown; J) light-phase riser to stage above the one shown; K) baffles for trapping phases.

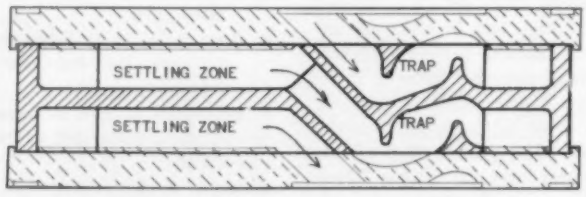
Extraction pilot plants are generally used either to make complete process variable studies or to compare feeds for the manufacture of a given product. When multicomponent feeds are used, it is easier to make these studies in a pilot unit than it is to determine the solubility and equilibrium relationships necessary for calculating results. It is important that the number of theoretical stages in the extractor be accurately known and reproducible over a wide range of processing conditions. Most modern extraction pilot plants use either packed or internally agitated countercurrent towers or batteries of mixer-settler units. However, the efficiency of towers varies greatly with phase properties and flow rates (*1, 2, 3, 4, 5*) while the mixer-settler units are usually very complex (*6*) if more than about seven stages are used.

The present type of mixer-settler extractor has been designed to meet the requirements of the ideal pilot extractor. This unit permits experimental determination of both the equilibrium and operating lines for any type of liquid-extraction process and permits a complete analysis of the operation.

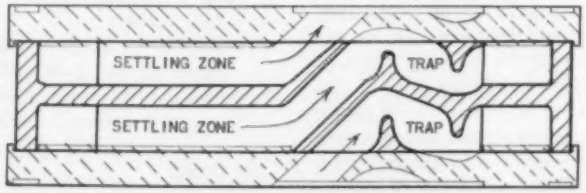
Some important features of these units are

1. Flow of the phases through the unit is caused by the gravity differential between the phases. Thus pumps and level controllers are eliminated.

2. Mixing of the phases is done by mechanical mixers which give a uniform mixing effect throughout the entire mixing zone and minimize



SECTION A-A: HEAVY PHASE DOWNCOMERS



SECTION B-B: LIGHT PHASE RISERS

Fig. 2. Interstage conduit cross sections.

R. B. Long is associated with Standard Oil Development Co.

phase by-passing or production of nonuniform dispersions. The mixing intensity is variable to get adequate mixing without producing emulsions which are difficult to settle.

3. Flow through the mixing zone is cocurrent. This allows 100% stage efficiency to be approached very closely but does not permit the stage efficiency to go over 100%.

4. Flow between the stages is countercurrent to get the full effect of stagewise operation.

5. Traps prevent backflow of the phases or by-passing of any of the stages. These traps insure the desired flow paths at low or high solvent-to-oil ratios or at low flow rates.

6. The depth of the phases in the mixing and settling zones is minimized since both mixing and settling are better in shallow layers.

7. The unit has a low holdup-to-throughput ratio. Short times are required to reach equilibrium and small quantities of feed can be processed efficiently.

8. Phase sampling taps enable the phases leaving any stage to be sampled and analyzed.

9. Flow paths through the unit are streamlined to minimize pressure drop and maximize capacity.

10. The unit is symmetrical so that heavy or light solvents can be used.

11. The unit is so arranged that feed or solvent can be injected into any stage allowing rapid change in the number of operating stages and the distribution of enriching and stripping stages.

12. The temperature pattern through the extractor can be controlled.

Construction Features

In general, the extractor consists of twenty mixer-settler stages positioned one above the other. The heavier (or more dense) phase enters at the top and flows down through the stages by gravity; the lighter phase enters at the bottom and rises through the extractor. The two phases flow countercurrently through the extractor, but concurrently through the mixing and settling zones of each stage. The countercurrent flow between the stages is obtained by conduits that conduct the heavy phase to the stage below, and the light phase to the stage above. Figure 1 shows the relationship of these parts.

The phases are mixed by two horizontal perforated plates located in each mixing zone. These plates are moved rapidly up and down to bring about the desired mass transfer without the production of emulsions which will not settle. Both the frequency and stroke of the reciprocating mixer are variable. The heavy-phase interstage conduit is shown as Section A-A in Figure 2 while the light-phase interstage conduit is Section B-B.

Between the two stage units (or "decks") are heating-cooling plates to control temperature. The relationship of the heating-cooling plates to the extraction decks is shown in Figure 3. Heating, cooling is accomplished by flowing a heat-transfer fluid through passages in these plates. Any desired temperature pattern can be established in the extractor.

A vertical shaft through all stages moves the mixer plates of each stage. This shaft is connected at one end to a reciprocating piston driven by a variable eccentric on a motor-driven shaft, and enters the extractor through a high pressure water-cooled stuffing box.

Each stage is provided with two sampling taps, equipped with a dipper tube designed to reach the liquid found in the highest part of the light-phase conduits and the lowest part of the heavy-phase conduits. The tubes thus sample the settled light and heavy phases as they leave a stage.

When equilibrium conditions are reached in the mixing and settling zones, the samples taken from the conduits leaving any stage correspond to coordinates on the equilibrium curve. Samples of the light phase entering the mixing zone together with samples of the heavy phase leaving the same mixing zone correspond to coordinates on the operating line. Similarly, samples of the heavy phase entering a mixing zone together with the light phase leaving the same mixing zone will correspond to coordinates on the operating line. In this way, the experimental equilibrium curve and the operating line for actual conditions in the extractor can be obtained.

The extractor can be operated with the heavy phase predominant (over-all interface at the top), or with the light phase predominant (over-all interface at the bottom), or with the over-all interface held at an intermediate location.

The feed and solvent can be introduced on any stage. Different proportions of stripping and enriching stages can thus be arranged, and by proper choice of solvent inlet from 1 to 20 stages can be used without changing the extractor assembly. It is also possible to use an antisolvent with this extractor, for it is a simple matter to inject it into any of the stages. Similarly, the extractor can be used with single or double solvent systems. When liquids are fed to intermediate stages of the extractor, they are fed directly into the mixing zone.

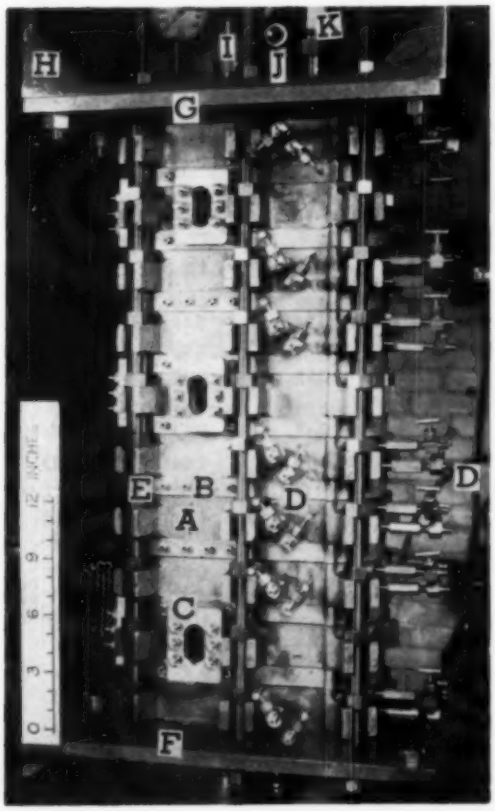


Fig. 3. Closeup of main body of twenty-stage extractor. A) two-stage extraction unit; B) heating-cooling plate; C) windows into unit; D) sample taps (all stages have since been provided with these taps); E) ¾-inch bolts holding extraction units together; F) bottom plate of extractor; G) top plate of extractor; H) top assembly housing; I) light-phase exit line; J) heavy-phase inlet; K) water-cooled stuffing box.

The extractor was designed for a working pressure of 300 lb./sq.in. gauge at 150° F. with a safety factor of 5. The windows have a working pressure rating of 400 lb./sq.in. The shaft stuffing box operated satisfactorily under this pressure and the hydraulic drive had enough power to drive the mixer shaft easily. One of these extractors has given more than 8,000 hr. of trouble-free service with the use of mainly liquid ammonia solvent at 250 lb./sq.in. gauge.

The total liquid holdup of the extractor section from top to bottom plates is 12 liters. To this should be added about 1 l. for the holdup in each of the top and bottom sightglasses. The holdup of each stage is 600 ml.

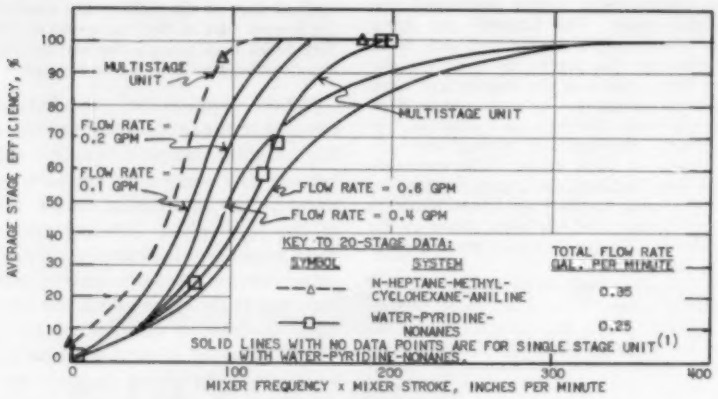


Fig. 4. The effect of flow rate and mixing intensity on stage efficiency.

Efficiency of Extractor

The 20-stage extractor was tested for efficiency with two systems: (1) water-pyridine-Pennsylvania nonanes cut, and (2) *n*-heptane-methylcyclohexane-aniline. The phase samples from the first system were analyzed by the method of Schultze (*7*) while the samples from the second system were analyzed by acid extraction and refraction index (*8*). The efficiency data for the water system are in Figure 4 and the efficiency data for the aniline system are illustrated in Figure 5.

Stage efficiencies in the region of 95 to 100% were easily reached at high throughputs with both of these systems. This stage efficiency is the ratio of the concentration change in an actual stage to the concentration change which would be obtained in that stage with perfect mixing and settling. With the mixers shut off the stage efficiency was only 2% for the water system and 5% for the aniline system. This shows that the high stage efficiency normally obtained in this extractor is due almost entirely to the action of perforated mixer-plates and not to turbulence caused by flowing the phases through the extractor. The high value (1.5 to 3.0) of the distribution coefficient for pyridine between water and nonanes limited the number of stages which could be reliably tested with this system to about four. The rest of the stages were grouped in "pinch points" where the operating line intersected with the equilibrium curve. However, with the aniline system (see Figure 5) almost the entire 20 stages were useful. A few stages at each end were involved in an operating line-equilibrium curve "pinch." In Figure 5 the compositions of the settled phases leaving the stages in Runs 9 and 10 correspond very closely to points on the equilibrium curve. Furthermore, all the stages in the extractor are practically equivalent to one another in stage efficiency. When operating under conditions approximating total reflux operation (operating line is $X = Y$ line), the 20-stage extractor gave solvent-free products of 0.4 and 99.7 wt. % methylcyclohexane at a total phase rate of 0.33 gal./min. The separation factor, beta, for this system is only about 1.5. The practically identical efficiencies obtained with the operating lines on opposite sides of the equilibrium curve show that the equilibrium data are reliable. Run No. 11 illustrates operation on the aniline system with no mixing action. The entire 20 stages of the extractor are here equivalent to only one theoretical stage.

Table 1.—Summary of Capacities with Intense Mixing

Temperature = 24-26° C., in all cases; Mixer Stroke = 0.31 in.; Mixer Frequency = 600 cycles/min.

System	Density, g./cc.	Viscosity, Centipoise	Phase Density Difference, g./cc.	Interfacial Tension, Dynes/cm.	Maximum Rates gal./min. for heavy-to-light phase volume ratio of		
					0.33	1.0	3.0
Nonanes	0.756	0.67	0.241	25-30	0.22	0.15	0.08
Water	0.997	0.89			0.08	0.15	0.22
Nonanes	0.756	0.75	0.354	12	0.34	0.15	0.07
Ethylene Glycol	1.110	12.7			0.11	0.15	0.20
Methanol-Water	0.955	1.24	0.590	1	0.53	0.35	0.17
Carbon Tetrachloride	1.545	0.88			0.17	0.35	0.53
Methanol	0.797	0.62	0.058	5-6	0.10	0.04	0.017
150-Neutral Oil	0.855	31.0			0.03	0.04	0.05
Light Oil	0.829	6.57	0.296	4	0.02	0.013	0.007
Ethylene Glycol	1.125	13.8			0.007	0.013	0.02
n-Heptane	0.697	0.40	0.293	2	0.48	0.26	0.11
Aniline	0.990	2.57			0.16	0.26	0.34
Nonanes	0.761	0.84	0.064	6	0.09	0.05	0.03
Methanol	0.825	0.82			0.03	0.05	0.08
Light Oil	0.822	6.67	0.177	9	0.03	0.02	0.01
Water	0.999	0.91			0.01	0.02	0.03
150-Neutral Oil	0.863	55.4	0.138	29	0.009	0.006	0.003
Water	1.001	0.91			0.003	0.006	0.009

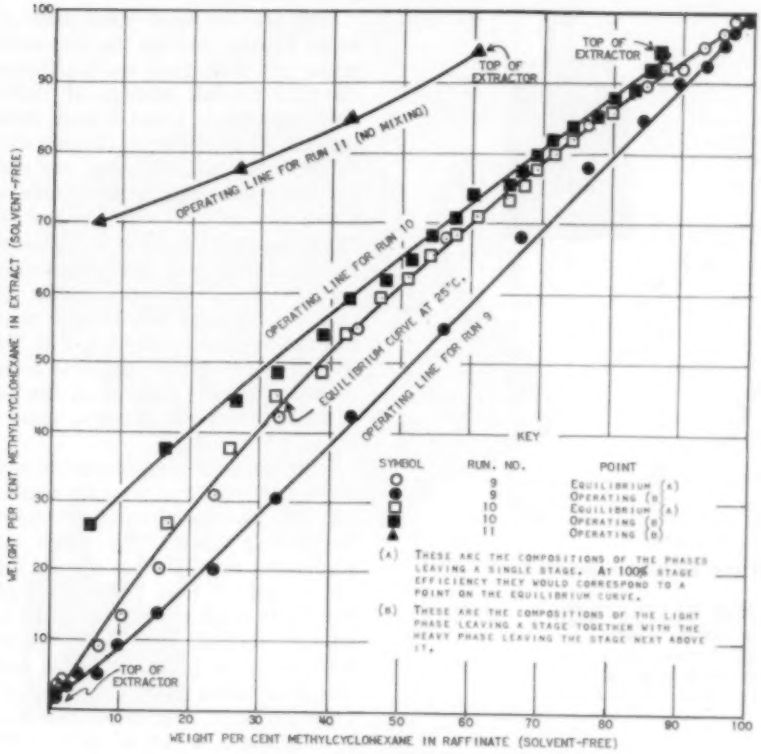

WEIGHT PER CENT METHYLCYCLOHEXANE IN EXTRACT (SOLVENT-FREE)
WEIGHT PER CENT METHYLCYCLOHEXANE IN RAFFINATE (SOLVENT-FREE)
TOP OF EXTRACTOR
TOP OF EXTRACTOR
TOP OF EXTRACTOR
OPERATING LINE FOR RUN 11 (NO MIXING)
OPERATING LINE FOR RUN 10
EQUILIBRIUM CURVE AT 25°C.
OPERATING LINE FOR RUN 9
KEY
SYMBOL RUN. NO. POINT
9 EQUILIBRIUM (a)
9 OPERATING (b)
10 EQUILIBRIUM (a)
10 OPERATING (b)
11 OPERATING (b)
(a) THESE ARE THE COMPOSITIONS OF THE PHASES LEAVING A SINGLE STAGE. AT 100% STAGE EFFICIENCY THEY WOULD CORRESPOND TO A POINT ON THE EQUILIBRIUM CURVE.
(b) THESE ARE THE COMPOSITIONS OF THE LIGHT PHASE LEAVING A STAGE TOGETHER WITH THE HEAVY PHASE LEAVING THE STAGE NEXT ABOVE IT.

Fig. 5. Operating diagrams for the aniline efficiency runs.

The stage efficiencies of the 20-stage extractor with the water-pyridine nonanes system have been compared in Figure 4 with those obtained from a single-stage extractor with an identical mixing zone. The frequency-stroke product (abscissa) characterizes the intensity of mixing over a wide range of combinations of frequency and amplitude values (*9*).

The mixing intensity needed to reach 100% stage efficiency varied with the feed rate to the unit. As total feed rate was decreased from 0.6 to 0.1 gal./min. in the single-stage unit, the frequency-amplitude product required for 100% stage efficiency decreased from about 300 to 130 in./min. for the water-nonanes system. However, at all flow rates under 0.3 gal./min. 100% stage efficiency was obtained if the mixing intensity was 200 in./min. This means that for a given mixing intensity a wide range of throughputs is obtainable without changing the stage efficiency.

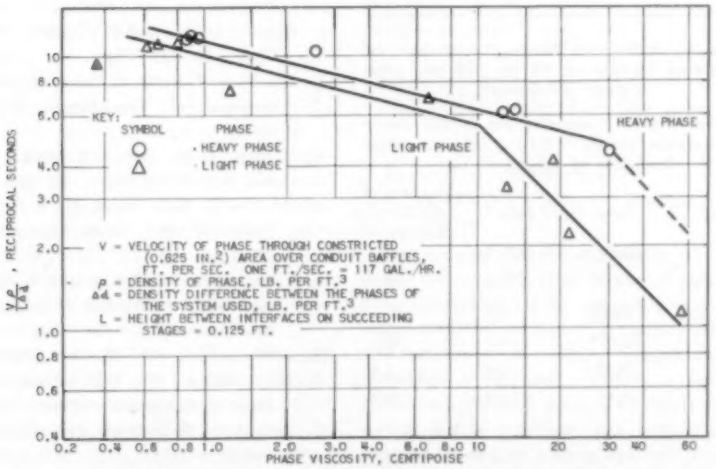

KEY:
SYMBOL PHASE
HEAVY PHASE
LIGHT PHASE
HEAVY PHASE
LIGHT PHASE
V = VELOCITY OF PHASE THROUGH CONSTRICTED (0.625 IN.²) AREA OVER CONDUIT BAFFLES, FT. PER SEC. ONE FT./SEC. = 117 GAL./HR.
ρ = DENSITY OF PHASE, LB. PER FT.³
Δρ = DENSITY DIFFERENCE BETWEEN THE PHASES OF THE SYSTEM USED, LB. PER FT.³
L = HEIGHT BETWEEN INTERFACES ON SUCCEEDING STAGES = 0.125 FT.
PHASE VISCOSITY, CENTIPOISE

Fig. 6. Correlation of maximum individual phase rates for the prediction of phase throughputs with no mixing.

Capacity of the Extractor

The capacity of the extractor is important for it determines how long it takes to make an extraction or to obtain a reasonable size product sample. As an illustration, it takes about 5 hr. to make a 20-stage extraction with a lube-phenol system and about 1 hr. for a similar run on the *n*-heptane-methylcyclohexane-aniline system. In order to determine the effect of physical properties of the phases on the capacity of the extractor, maximum rate data were obtained for the test systems in Table 1 with and without mixing. These test systems covered a 10-fold range in density difference between the phases, a 100-fold range in viscosity, a 25-fold range in interfacial tension, and a 2-fold range in density of the phases.

These data were obtained at a frequency-stroke product of about 200 which is sufficient to reach 100% stage efficiency for the water-nonanes system at any total phase throughput under 0.25 gal./min. This is much more mixing than is necessary for low throughputs

or for systems easy to mix and, consequently, the maximum throughput values reported in Table 1 may be considerably lower than can actually be achieved under the optimum mixing intensity-capacity conditions.

The maximum throughput of a system with just sufficient mixing to give 100% stage efficiency can be expressed as a percentage of the throughput without mixing. For systems difficult to mix, the value of 40%, and for systems easy to mix, the value of 65% of the nonmixing throughput is used to determine maximum capacity. At any throughput lower than these values, the stage efficiency of the extractor will be 100%, with optimum mixing.

The nonmixing data for the various test mixtures have been correlated empirically with the physical properties of the phases in Figure 6. In the development of this correlation it was found that plotting the corresponding maximum light- and heavy-phase rates against each other gave straight lines. Furthermore, if these phase rates were divided by the density difference between the phases and plotted as before, a single intercept resulted for a given phase regardless of the other phase present in the unit.

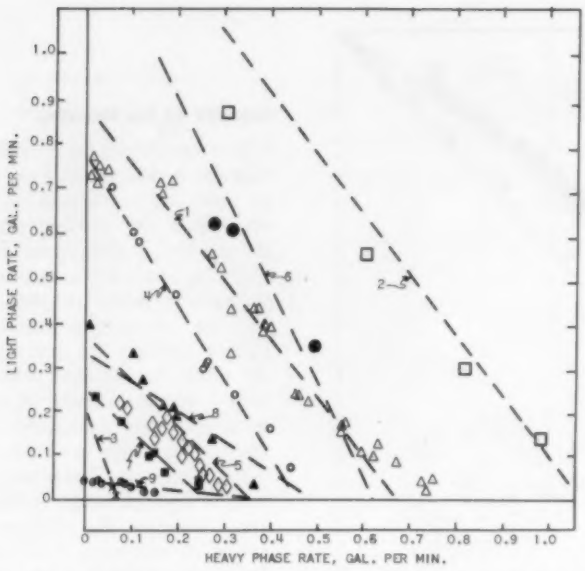


Fig. 7. Comparison of experimental and predicted capacities.

Key:

1. △ Water-nonanes
2. □ CCl_4-methanol
3. × Methanol-150 neutral
4. ○ Glycol-nonanes
5. ◇ Glycol-light oil
6. ● Aniline-n-heptane
7. ■ Methanol-nonanes
8. ▲ Water-light oil
9. ◑ Water-150 neutral

By the use of Figure 6 maximum flow rates for the heavy and light phases are determined from their physical properties. These values are then used as intercepts on a plot of light-phase vs. heavy-phase rate. A straight line is drawn between these intercepts to define the entire capacity curve. Figure 7 shows a comparison between the experimental data and the throughput curves obtained from the correlation in the above-mentioned manner.

The capacity with mixing just adequate to give 95-100% stage efficiency is determined by drawing a line parallel to the no-mixing line through intercepts 40% of the no-mixing values for systems difficult to mix and 65% for systems easy to mix. On this basis, the table of estimated throughputs with satisfactory mixing reported as Table 2 has been prepared for a water-oil system. These data were calculated from the empirical correlation in Figure 6 based on a density difference of 0.1 g./cc., and with the assumption that this system is difficult to mix. These data show that the extractor has good capacities even with systems having high viscosities and relatively low density differences between the phases. Product rates of 2 to 5 gal./hr. are readily obtainable with such systems.

Experience with this type of extractor has shown that the maximum throughputs with a given phase-rate ratio and with a fixed mixing intensity are essentially independent of whether the over-all interface is maintained at the top or at the bottom of the extractor. However, greater operating stability is obtained if the phase which tends to take up most of the flow cross-section (the phase offering the greatest resistance to flow) is made the continuous phase.

In all the maximum rate determinations the flow rates were never limited directly by settling difficulties or entrainment but always by hydraulic considerations. The slanted surfaces of the interstage conduits were effective in breaking up dispersions and served as an efficient final settling zone for the most persistent dispersions encountered.

Table 2.—Estimated Throughputs for an Oil-Water System at 95 to 100 per cent Stage Efficiency

Based on Figure 7 assuming the density difference between phases = 0.10 g./cc. and phase flow ratio by volume = 1.0

Temp. ° F.	Total Phase Rate * gal./min.	gal./hr.	Viscosity of Oil Phase Centipoise
75	0.021	1.3	55
100	0.039	2.3	29
140	0.079	4.7	12
180	0.10	6.0	5.5
220	0.11	6.7	3.3

* The total phase rate was determined by assuming that with good mixing the throughput was 40% of the nomixing rate.

Heat Transfer

Heat-transfer tests were made with water flowing through the heat-transfer plates, and with water and a 150-neutral oil (150 Saybolt seconds at 100° F.) alternately as the phase flowing through the unit. Temperature gradients of 40° F. over the extractor from one end to the other were readily obtainable with a mean-temperature difference of about 40° F. between the water in the heating-cooling plates and the phase flowing through the extractor. During these tests the extractor was brought to thermal equilibrium in about 1 to 2 hr. There was little conductivity of heat between stages. The heat capacity of the entire extractor filled with water is about 110 B.t.u./° F.

With water flowing inside the extractor the over-all heat-transfer coefficient per heat-transfer plate varied from 10 to 15 B.t.u./(hr.)(° F.). This corresponds to a value of from 40 to 60 B.t.u./(hr.)(sq.ft.)(° F.). With the oil phase flowing through the extractor, the over-all coefficient per plate was from 3.4 to 6.4 B.t.u./(hr.)(° F.), which corresponds to values of 14 to 26 B.t.u./(hr.)(sq.ft.)(° F.). A large number of combinations of flow rate of the heat-transfer fluids was used in getting these data. Heating and cooling data were obtained, but the over-all coefficient of heat transfer appears independent of the type of operation. The heat-transfer coefficient was also found to be independent of the mixing intensity inside the extractor.

Acknowledgments

The authors wish to express their appreciation to the Esso Laboratories of the Standard Oil Development Co., which sponsored this work and permitted publication of the results and to R. A. Rusk of the Pennsylvania State University for his help in solving the mechanical design and construction problems which were encountered.

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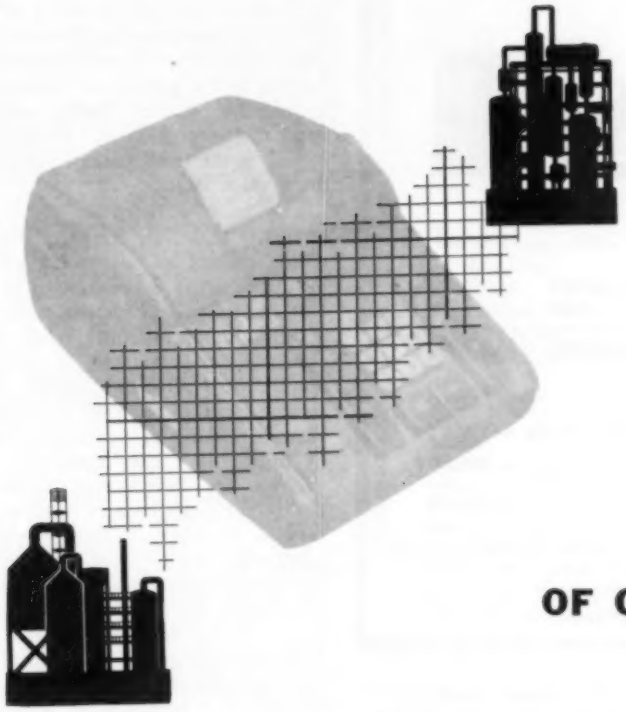

comparison OF CHEMICAL AND PETROLEUM accounting IN ANALYSIS OF NEW PLANT ECONOMICS

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Since the birth of the petrochemical industry in 1924-25, when that vast chemical raw material reservoir–crude oil–was first tapped to produce chemical end products on a commercial scale, the chemical and oil industries have felt a growing need for a better understanding of each other's basic accounting problems and techniques. Such a relationship has become necessary because of the ever increasing interdependence of these two industries in regard to raw materials for their respective processing schemes.

Oil companies, in order to price properly their potentially valuable hydrocarbon raw materials, have made it a point to know to some extent the value of these raw materials to a chemical company. By the same token, these chemical companies familiarized themselves with petroleum refining techniques and accounting practices in order to understand better the value of hydrocarbon components to an oil company.

The purpose of this paper is to set down some of the similarities and differences in accounting techniques used by the oil and chemical industries in compiling economic evaluations of proposed ventures for presentation for capital expenditure.

To this end a number of the fundamental similarities and differences between techniques and practices of the oil and chemical companies have been applied to calculations on the profitability of manufacturing acetylene from natural gas. The basic data on acetylene economics used in the comparison appeared in two articles, "Recent Developments in Wulff Acetylene" (*1*) and "The Wulff Process for Acetylene from Hydrocarbons" (*2*). The first article mentioned which concerns the production of 50,000,000 lb./year of acetylene by once-through cracking of natural gas is especially pertinent to this paper.

Process

Briefly, a description of the once-through cracking process of natural gas is as follows.

Two cracking furnaces containing refractory masses are used alternately in a cyclic regenerative technique to crack natural gas in the presence of dilution steam. While one furnace is being heated to cracking temperatures by combustion of fuel gas, the other is engaged in releasing the heat so stored for pyrolysis of natural gas to acetylene. The cracked gases from the furnace on cracking cycle, which operates under vacuum, are quenched for condensation of most of the dilution steam and for the small amount of liquid products and tars formed during the pyrolysis. The remaining gas is compressed to atmospheric pressure, is cooled, and then passes to a gas holder. At this point the gas stream contains about 7 mole % acetylene. From the gas holder the cracked gases pass to the acetylene recovery plant where the cracked gas is compressed and processed to remove diacetylenes in a selective solvent. The gas then passes to the acetylene absorber where DMF is used as absorbing oil, and the solvent leaving the absorber is subjected to selective stripping. Material less soluble than acetylene is removed and some is used as fuel gas for reheating the furnaces. The acetylene product (99+ mole % purity) is sent to a gas holder, and gases which are more soluble than acetylene are removed by stripping with natural gas. The stripped solvent is reused in the diacetylene and acetylene absorbers.

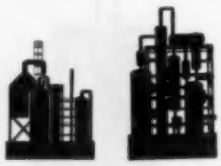
Economics

It should be pointed out before the economics of acetylene manufacture is discussed that although most of the basic capital and operating data were secured from the Lummus Company article (*1*), certain liberties have been taken with some of its figures to illustrate better the similarities and differences in oil and chemical company approaches to the economics of new ventures. It is strongly

TABLE 1.—

ACETYLENE FROM NATURAL GAS

(50 million pounds per year)



Capital Investment	Oil	Chemical
Permanent Investment		
1. Acetylene process plant	$6,057,000	$6,057,000
2. Real estate	3,000	3,000
Total	$6,060,000	$6,060,000
Allocated Investment		
1. Steam	.....	$1,652,000
2. Water	.....	50,000
3. Electricity		60,000
4. General facilities	.....	300,000
Total		$2,062,000
Working Capital (⅛ of annual expense)	.....	627,000
Total Investment	$6,060,000	$8,749,000

recommended that anyone interested in the economics of acetylene manufacture refer to the original articles heretofore mentioned.

CAPITAL INVESTMENT

Total capital investment for a project (see Table 1) may conveniently be divided into three categories, namely (1) permanent or fixed investment, (2) allocated investment, and (3) working capital.

All other circumstances being equal, there is no reason to assume that permanent investment should receive different treatment either by an oil company or a chemical company. It should be noted that the permanent investment indicated for the acetylene process plant and the necessary land have been identical for both industries. It is assumed in both cases that offsite capital expenditures have been included in the basic acetylene process plant investment.

The assumption has been made in these analyses that service facilities now exist in both cases for the production of the required utilities, namely steam, electricity, cooling water, and process water. It is the practice of some oil companies to include in the utility rates employed in considering new projects a certain return on the permanent investment for existing service facilities. On the other hand, chemical companies in general charge utilities at cost of production, excluding any profit factor for service facilities and also including in the total capital investment an allocated investment. This latter figure represents that portion of the permanent investment in an existing service facility which reflects the proportion of the utility consumed to the total amount generated in the service facility.

The utilities listed in Table 2 are indicated at an oil company unit price which reflects an approximate average of utility costs encountered. It is the custom of many oil companies to include a profit factor in utility costs. On the chemical company side, to develop an approximate allocated capital for the service facilities required for these cases, factors relating to capital cost per unit of utility have been employed. These factors are based approximately on multiplant experience in construction of service facilities. Although individual cases vary widely from the capital cost per unit of utility employed, these cases will suffice for the purposes of this article. In the development of chemical company unit prices for utilities, it has been assumed that a 15% return on allocated capital, before taxes, has been applied to the oil company unit costs. Therefore, deducting this return from the oil company unit costs would result in chemical company unit costs which reflect only actual costs incurred in utility generation.

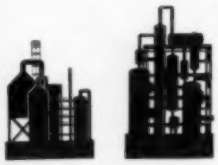
It should be emphasized that the allocated capital in this case is not capital for new utility facilities construction but only the allocated portion of facilities now in existence. Allocated investment for general facilities includes that portion of the permanent investment in main office buildings, mechanical shops, fire protection, and other facilities not covered in the utility allocated investments indicated, which apply to this project in proportion to their total value.

Working capital, of course, is the amount of cash required to enable the business to function properly as regards day-to-day payments and credit extensions, and allowances for inventories of raw materials and finished products.

In general, oil companies do not include provision for working capital in their economic appraisals presented to management for appropriation of capital funds. By no means however is the consideration of working capital ignored as the comptroller or other appraising official certainly makes allowances for any undue requirement of working capital. A departure from this generalization may be found occasionally in considering, for instance, a sizable inventory of a valuable catalyst, which would, of course, if large in value in comparison to the total capital expenditure, be included in working capital.

TABLE 2.—

UTILITIES



	Quantity	Units	Unit Price Oil	Unit Price Chemical
Steam, 600 lb./sq.in.	165,200 lb./hr.	$/M lb.	0.40	0.20
Electricity	401 kw.	$/kw.-hr.	0.007	0.0042
Cooling water	12,000 gal./min.	$/M gal.	0.015	0.014
Process water	90 gal./min.	$/M gal.	0.15	0.14

Allocated Capital—Utilities

Steam:	$10/lb./hr. × 165,200	= $1,652,000
Electricity:	$150/kw. × 401	= 60,000
Water:		50,000

On the other hand, the general rule for chemical companies is to include working capital in their economic evaluations, no matter how small in relation to the over-all capital investment of the project. Various methods of determining working capital are used. Probably the soundest approach to the problem is made by those companies which actually analyze the various components of their anticipated operations for the particular project where working capital is required. An approach of one company is represented by the following formula, which is the sum of (1) 30 days raw materials costs; (2) 30 days out-of-pocket operating expense; (3) 30 days finished products inventories; and (4) 30 days accounts receivable.

Of course, even this formula, if adhered to with no deviations, is subject to error, particularly in cases where seasonal markets exist and product inventories may accumulate for as long as four to six months. Others calculate working capital as a per cent of total annual sales or as a per cent of total annual expense (raw materials, direct and indirect expenses). For illustration, in this case working capital has been used derived as 25% of total annual expense. It is of interest to note that if working capital is figured on the 30-day basis outlined above, it would amount to $948,000.

The total capital investment of the chemical company, on the basis described above, is $2,689,000 more than that of the oil company, but it should be borne in mind that $2,062,000 of the difference can be accounted for in part by higher utility costs to the oil company.

TABLE 3.—

RAW MATERIALS

	Quantity	Unit Price	Dollars/Yr.
Natural gas, million B.t.u./day	17,250	0.175/million B.t.u.	$993,000
Credits:			
Fuel gas, million B.t.u./day	11,750	0.175/million B.t.u.	676,000
Oils and tars, lb./day.	25,000	0.012/lb.	30,000
Total credits			$706,000
Net raw material charge			$287,000
Net raw material charge, $/lb. acetylene			.0057

Raw Materials

Raw materials may, for the purposes of this explanation, be divided into two categories: (1) purchased raw materials and (2) captive raw materials.

In the use of purchased raw materials, no problem exists in pricing the raw material into the process since naturally it is charged in at purchase price.

In considering the use of captive raw materials, both oil and chemical companies use three different methods depending on the occasion.

1. sales value if the raw material could be marketed as a finished product, and if the market could absorb the volume indicated at the market price.
2. manufacturing cost if the raw material would be produced by currently idle facilities.
3. incremental cost if the raw material could be produced on a unit now operating below capacity.

In a consideration of the costing of captive raw materials into a process on a manufacturing or incremental basis, one is confronted with what is probably the greatest and most basic difference between oil and chemical company practices. In order to understand this difference in costing raw materials and to realize why the difference exists, the basic nature of the processing schemes utilized by both industries and their costing systems should be explained.

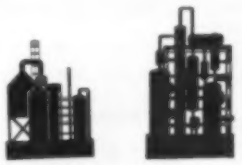
In general, processing in the chemical industry is based on reacting two or more raw materials in a well-defined plant layout in order to produce one major product. The raw materials, if purchased, are readily costed into the process. The unit cost of production is readily established since operating labor, maintenance, utilities, and other factors are easily measured and directly attributable to the manufacture of one major end product. Coproducts, defined as materials produced in the same process in relatively equivalent volumes, do not occur to any great extent in chemical processing. Thus, very simply, raw materials plus processing cost equals cost of finished product. Of course, the allocation of overheads and the valuing of by-product streams, if any, may influence the cost of the end product, but, in general, the problem is relatively simple.

cost estimation

The oil companies, on the other hand, are faced with an exceedingly different, far more complex, problem of cost ac-

TABLE 4.—

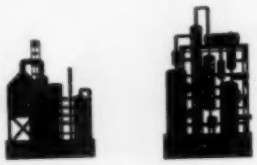
UTILITIES AND OTHER DIRECT COSTS



	Dollars/Year	
	Oil	Chemical
Steam	$520,000	$260,000
Electricity	22,100	13,200
Cooling water	85,000	79,000
Process water	6,400	6,000
Solvent make-up (450 lb./day @ 33¢/lb.)	49,000	49,000
Operating labor plus supervision	214,000	214,000
Payroll burden	42,800	42,800
Maintenance (labor plus supplies)	303,000	303,000
Royalty	125,000	125,000
Total direct costs, exc. fd.	$1,367,300	$1,092,000
Total direct costs, $/lb. acetylene	.0273	.0218

TABLE 5.—

INDIRECT COSTS



	Oil	Chemical
General plant overhead (30% of direct Exc. feed)	$410,000	$358,000
Depreciation, 10%/yr.	605,700	605,700 *
Interest on capital	....	....
Taxes and insurance, 2%/yr.	121,200	121,200
Total indirect costs	$1,136,900	$1,084,900
Total indirect $/lb. acetylene	.0227	.0217

* Additional depreciation on allocated investment included in utility costs.

counting. A single raw material–crude oil–is fractionated, and the products therefrom are cracked, polymerized, alkylated, treated, and extracted to produce a myriad of end products. Although the cost of this crude oil is definitely known, the processing of the various products in a typical oil refinery is so complex and interdependent that accurate breakdowns of unit costs are next to impossible. The major problem, of course, is encountered when one material is split into two: should the processing cost be allocated to the two products on a weight or a volume basis, or, if one is an overhead product from a fractionation, should it stand all the steam costs required for the fractionation? One is reminded of the analogy of the oil refinery to a slaughter house. When a pig is cut up into pork chops and bacon, how much did the pork chops cost and how much did the bacon cost?

The complications in such processing schemes have led the oil industry to develop a number of procedures for costing which consider mainly different methods of allocating total refining or production cost to the total number of products by many and widely varying methods. One might say that as many different systems exist as there are oil companies to use them. Uniform accounting methods in the oil industry may never be a reality. There is considerable resistance to changing an accounting system in an oil company due to its complexity, to the normal resistance to changing an existing system that one has used for years, and to the enormous costs that changing over to a new system would entail. A number of major cost accounting patterns in the oil industry have been made and presented (*3*). The basic approaches to such systems are as follows:

TABLE 6.—

COST SUMMARY

	Oil		Chemical	
	$/yr. (thousands)	$/lb. Product	$/yr. (thousands)	$/lb. Product
Feedstock	$ 287.0	.0057	$ 287.0	.0057
Direct costs	1,367.3	.0273	1,092.0	.0218
Indirect costs	1,136.9	.0227	1,084.9	.0217
Total annual expense (Net Bulk Cost)	$2,791.2	.0557	$2,463.9	.0492
Sales & admin. expense (1% of sales @ 10¢/lb.)	50.0	.0010	50.0	.0010
Total cost of sales	$2,841.2	.0567	$2,513.9	.0502

1. All products cost the same except fuel gas which is valued at market.
2. The same profit as per cent of cost is realized on all products except fuel gas (or fuel gas and fuel oil) which is valued at market price.
3. All products except gasoline are assigned market value and cost of motor gasoline is calculated by difference.
4. Replacement costs are calculated from data which consider cracking crude oil to ultimate yield of gasoline and No. 6 fuel; no intermediates are produced such as kerosene and heating oil. The cost of crude and the market value of No. 6 fuel are known, and by the application of a hypothetical conversion cost (generally based on experience), the replacement cost of gasoline may be computed. All other products are assumed to have a definite ultimate yield of gasoline and No. 6 fuel oil on cracking, hence with a consideration of the market value of this fuel oil, the previously calculated replacement and hypothetical conversion cost of gasoline, the replacement cost of the other products may be calculated.

All degrees of complexity of the above schemes may exist. In fact, with the use of these different schemes on a typical refinery product distribution, differences were calculated in gasoline cost based on a 12 cent/gal. market of from 8.66 cents/gal., when all products were costed equally to 11.91 cents/gal. on the replacement cost basis. Of course, total operating cost remains unchanged, and since it is an allocation, when some products increase in cost by one method, the other products decrease in cost. It is apparent that, when manufacturing cost or incremental cost is used to cost a raw material, there may be a considerable variance in apparent profitability of a project even between oil companies themselves.

The oil industry is not, of course, unique in the complexity of its accounting problems. Some similar processes occur in the chemical industry, such as chemicals derived from brine, the Celanese oxidation process, and others.

In the particular case outlined in Table 3, the assumption is made that the chemical company purchased the natural gas at 17.5 cents/million B.t.u., and the oil company diverted natural gas from sales at 17.5 cents/million B.t.u. This assumption keeps the two industries on an even footing as regards raw material costs, so that in a final analysis one may more clearly indicate the effect of accounting factors on economic appraisals without confusing the issue with one company's inherent raw material advantages.

By-Products

This acetylene process produces two by-products, a low B.t.u. value gas, and a small amount of oils and tars. Some

companies include by-products as a credit under sales, and others apply them to reduce cost of manufacture of the major end product. The over-all project profitability, of course, would be the same, except that in one case, the cost of manufacture would be higher. In this case, the by-products have been applied as a credit against raw material costs.

Utilities and Other Direct Costs

Utilities (steam, electricity, cooling and process water) differ between the oil and chemical company cases (previously calculated), as shown in Table 4, in an amount which reflects the oil company's inclusion in its utility costs of the previously assumed 15% return before taxes on allocated utility capital. All other elements of direct cost are identical for both cases.

Indirect Costs

Again the practices of oil and chemical companies did not show any significant differences in methods of calculating direct costs. Interest on capital (see Table 5) is included as a heading with no costs indicated to emphasize the fact that in general neither oil nor chemical companies include interest in their economic appraisals of new projects that are presented to management for capital appropriations. Since, in general, the person responsible for preparing the economic appraisal may not know the particular source of capital that management would consider utilizing for his project (i.e., borrowing at 3%, selling stock at 6% or from retained profits), the concept of interest is left to management and no attempt is made to forecast ultimate profitability by assuming an arbitrary interest rate. Of course, if the source of capital funds is obvious to all concerned, undoubtedly it could be used in a presentation to management.

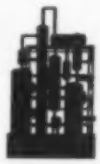
The cost summary (see Table 6) develops the total annual expense or net bulk cost from the sum of the feedstock and direct and indirect costs. Addition of sales and administrative expense at 1% of sales for both industries results in a total cost of sales for the oil industry of some $327,300 a year less than the chemical company, all of which in this case may be traced to the difference in handling utilities costs and capital investment.

The sales expense of 1% of sales is below both the oil and chemical general standards, but it has been assumed in both cases that the acetylene will be marketed to a very few customers under long-term contract.

Profitability Calculations

In a calculation of profitability of the acetylene venture, income taxes in both cases have been assumed at 52%. Individual income tax rates of both oil and chemical companies may vary significantly from this figure. For purposes of illustration however the same rate has been used for both industry groups to eliminate differences in economic comparison due to a nonaccounting variation in expense.

TABLE 7.— PROFITABILITY CALCULATIONS



	Oil		Chemical	
	$/yr. (thousands)	$/lb. Product	$/yr. (thousands)	$/lb. Product
Sales @ 10¢/lb.	$5,000.0	.1000	$5,000.0	.1000
Less cost of sales	2,841.2	.0567	2,513.9	.0502
Gross profit	$2,158.8	.0433	$2,486.1	.0498
Less taxes @ 52%	1,122.6	.0225	1,292.8	.0259
Net profit	$1,036.2	.0208	$1,193.3	.0239
Capital investment, fixed	$6,060.0		$8,122.0	
Capital investment, total	$6,060.0		$8,749.0	
Return on fixed investment, %	17.1		14.7	
Return on total investment, %	17.1		13.7	
Payout before taxes, years	2.19		2.46	
Payout after taxes, years	3.69		4.16	
Return on sales, %	43.3		49.8	
Turnover, %	82.5		61.7	

The fixed capital investment for the oil company, as developed previously, includes only the basic acetylene process plant and necessary land; and the chemical company capital includes, in addition, the allocated investment for utilities and general plant facilities. Total capital investment for the chemical company includes working capital.

Return on Investment

Return on investment is the ratio of profit to capital investment and is calculated by dividing annual profit by investment. A profitability calculation of this type enables management to measure directly the relative merit, say, of investing its capital in the project under consideration versus investing the same amount of capital in government bonds at about 3% interest (which is equivalent to return on investment before taxes).

Many different methods of computing return on investment are used. Annual profit may be profit before or after taxes, and investment may be fixed capital investment representing only that investment in physical plant, or may include working capital on the basis that working capital is actually in the nature of an investment in the project, even though in some cases it may be liquidated in a relatively short time.

Utilizing the profitability concept of return on investment is almost exclusively a chemical company approach, and is its most widely used concept of profitability. Few oil companies use it in presentation of projects to management for capital appropriations, but it is used quite widely by petrochemical subsidiaries or divisions of oil companies. However, return on investment for the oil company acetylene project has been included in Table 7 for direct comparison with the chemical company project.

Relatively few chemical companies consider return on investment based on annual profit before taxes. For this reason the returns on investment indicated in Table 7 are all based on annual profit after taxes or net profit.

Some chemical companies include both before-and-after-taxes bases in their appraisals, but prefer, or are more accustomed, to think in terms of return on investment based on profit after taxes.

A few chemical companies consider in their computation annual profit as profit after taxes plus depreciation, which is commonly referred to as "Cash Generated" or "Cash Return." This

concept has not been included in our presentation.

The profitability concept of return on investment based on fixed capital and on fixed plus working capital are both widely used in the chemical industry, and both have been illustrated here.

It is the practice of many chemical companies to consider in their economic presentations the fact that the plant will not be operating at full capacity for some period of time after start-up. In general, the economic presentations of the oil companies reflect only capacity operation. In view of the chemical company time-lag-to-capacity-production concept, it is the general practice to calculate the economics at a number of sales levels, each reflecting increasing sales per year over the base case of reduced sales during the first year. These increases are indicated on their economic appraisals as gradually increasing returns on investment for each year over a period of, say, the first five years of operation. This is undoubtedly a more accurate presentation of actual expected return on investment than a single figure at capacity operation and is of considerable assistance to management in forecasting and controlling balance sheets.

PAYOUT PERIOD

Payout period is a method of measuring cash return as opposed to return on investment, which is a measure of profit. Payout period, which is expressed in days or years, signifies the time lapse before the capital investment is recovered from the proposed project. Payout period is in most cases calculated by dividing the capital investment by the sum of depreciation plus profit after taxes; this sum reflects the cash actually generated into the company by the project. In a comparison of two projects, all other considerations being equal, the project having the shorter payout period is preferred.

Payout period is the major profitability concept used by oil companies and is, of course, based on fixed investment. This period is also widely used by the chemical companies as a concept of profitability in addition to return on investment. Both concepts are of importance in considering a venture. The return on investment reflects profit that would accumulate as a result of the venture, and payout period reflects, in addition to time required to recover the capital investment, the minimum time that must elapse before the company would break even should the plant's utility be terminated. In this case, it affords a measure of estimating the project's ability to withstand technical obsolescence which is, in general, of more importance to chemical companies than to oil companies.

Payout period, in both industries, is based on profit after taxes since a payout based on profit before taxes has no real significance, except where managements have become so accustomed to the concept that the complications of figuring net profit to the company after taxes to give real cash generated for application to paying out the investment has become a matter of course.

However, both bases have been indicated in Table 7 for comparative purposes.

Only a very few chemical companies base payout on fixed plus working capital, hence the payouts indicated have been based only on fixed capital. There is no correlation or agreement between the types of capital investment used for return on investment and payout: some companies use fixed for one and fixed plus working for the other, and still others use fixed plus working for both.

Some few chemical companies consider that construction time is added to the payout period since the first day of construction is the beginning of the expenditure of capital. A considerable number of companies consider that initial operations would in most projects be at a level below capacity operation, and thus the payout is calculated to take into account these factors. In this case a longer payout than that obtained by studying capacity operations from start-up would result, but it is probably the most accurate estimate of actual payout period.

RETURN ON SALES

Return on sales is a measure of the percentage reduction the sales price considered in the project may bear before the breakeven point is reached, or, in other words, before the gross profit disappears. Return on sales is calculated by dividing annual profit before taxes by annual sales volume. In a presentation of economics of new projects to management this concept is not used by oil companies, nor very often by chemical companies.

However, when a project is under study to enter a competitive field, it is universally understood that the greater the spread between sales value and cost of sales, the better the project and the more stable in a competitive field. Return on sales measures the cushion between sales and cost of sales, and, as such, may be a valuable tool. This is a case where the mental appreciation of spread between sales and cost of sales is used by all types of industries on all types of projects but is rarely reduced to a readily usable percentage figure.

TURNOVER

Turnover is a measure of sales volume per dollar of investment and is calculated by dividing annual sales by capital investment. No companies were encountered which actually utilize this profitability concept in presentation of new projects to management, but reference has been made to it here since it is discussed quite widely as a profitability concept in the literature. In actual use however a ratio of this type is more commonly employed as a guide in estimating construction costs for new products.

PROFITABILITY COMPARISON

It is of interest to note that, although all the elements of cost (feedstock, utilities, labor, depreciation, etc.) and the sales price of acetylene were believed to be the same for both companies, the apparent profitability differs considerably—a return on fixed investment of 17.1% for the oil company and 14.7% for the chemical company. Practically all this difference may be traced to an internal bookkeeping or accounting method in handling depreciation of utilities. If some of the other internal accounting concepts discussed were included in the economics presented here, the apparent profitability spread might have been widened between the oil and chemical companies. The fact remains, however, that both companies have the same cash inflow and output, and the actual over-all profitability is the same. This variance in profit, of course, would be the case between two chemical companies using different internal accounting procedures, or between two oil companies under the same circumstances.

It becomes obvious that to evaluate properly the profitability of a project in familiar terms to you, even though you may be familiar with a particular profitability concept within your own particular definition, it is well to be completely in the know with the basis of calculation used for the same profitability concept by another company if you are to compare the two.

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Presented at one-day meeting of New York Section, October 13, 1954.

HOUSTON

By A. B. Wintringham

Ethyl Corp., Pasadena, Texas

Bask in Florida-like climate at the Shamrock's luxurious swimming pool.

The National Meeting of the A.I. Ch.E., May 1-4, 1955, will be held at Houston's own Shamrock Hotel, with the South Texas Section as hosts. The beautiful Shamrock Hotel, built by oilman Glen McCarthy, is situated on the southwest corner of South Main and Holcombe Boulevard, four miles south of downtown Houston. Its strategic location is one of beautiful surroundings and easy accessibility. The new and modern municipalities of Bellaire, West University Place, and additions of Braeswood and Southern Oaks form residential surroundings on the west, while the magnificent buildings of Prudential Insurance Company, the Texas Medical Center and others are situated on the east.

Within a short distance of the Shamrock are many fine restaurants catering to every appetite. Many new motels are close by, since the hotel is just off the main arteries to Corpus Christi, San Antonio, Beaumont, Port Arthur, Fort Worth and Dallas.

Rooms will be available at the Shamrock and in downtown Houston at the Rice. Downtown Houston offers the best in theaters, playhouses, restaurants, symphonies and ballet for your evening entertainment.

How to Get Here

Major airlines serving Houston are Eastern, Braniff, Continental, Pan American, Delta-C & S, Pioneer, and Trans Texas. Through plane service from the West Coast is available through TWA-Braniff, and American-Continental interchanges. From the East, Eastern airlines runs direct nonstop flights from New York and Washington. Other points are served on a local basis.

The major rail lines are Sante Fe, Southern Pacific, Missouri Pacific, Rock Island, Fort Worth & Denver, and Missouri-Kansas-Texas lines. Through pullman service is available from New York and Washington via Pennsylvania-Missouri Pacific route, and from Washington via Louisville and Nashville-Southern Pacific interchange.

You'll find every pleasure a modern city affords, in interesting Houston.

LADIES PROGRAM

On Sunday, after you and your husband have registered, visit the ladies' booth in the Grecian Room (Sunday only) at the Shamrock Hotel. You and your husband are invited to join friends for the Get Acquainted Party held in the hotel at 6:00 p.m.

Plan to get an early start Monday with a 9:00 a.m. brunch by the luxurious Shamrock pool. From the hotel we leave on a mid-day tour through the campus of The Rice Institute, one of the six colleges and universities in the city. Next we will have a private showing at the Museum of Fine Arts. We feel this is a must, as without this you just wouldn't have seen Houston! We will then tour through the new Texas Medical Center. In the early afternoon there will be a tea and style show at the swank Petroleum Club atop the Rice Hotel. The style show will be presented by one of Houston's famous department stores. There will be theater parties Monday evening at the Alley Theater, which is "in-the-round."

On Tuesday there will be a four-hour boat trip from the turning basin at the end of the Houston Ship Channel to the San Jacinto Monument, with lunch served on the boat.

For those not interested in the boat trip, we have planned several brief tours to places of interest in the city. One will be to the Prudential Life Insurance Building to see the American Collectors exhibit at the Contemporary Art Museum and to lunch. Another will be to some of Houston's fashionable antique shops and to lunch. These tours will be without charge, except for lunch, which will be "Dutch treat." The evening entertainment will be "ranch style,"

One of the primary reasons for coming to an A.I.Ch.E. meeting . . . meeting with other chemical engineers.

Or . . . to catch up with the latest technical developments, there'll be a well-rounded program of papers.

including real southwestern barbecue, a performance by the renowned mounted Harris County Sheriff's Posse, strolling Spanish musicians, and fun for all.

Wednesday morning at 9:00 a.m. a bus departs for the River Oaks Country Club. Here you will have brunch at one of Houston's oldest and most fashionable clubs. There will be a brief tour through River Oaks' residential areas where many of Houston's most beautiful homes are located. No afternoon program has been planned for Wednesday, but the swimming pool and a card room at the Shamrock will be functioning.

The amazing Houston Ship Channel . . . site of much of the concentration of process industries.

PLANT TOURS

Visitors will have the unique opportunity of seeing much of the great Houston industrial area. One-fourth of the nation's oil refining capacity and 80% of United States petrochemical production is located on the Texas Gulf Coast. Houston, the largest city in the south and one of the country's fastest growing industrial cities, is the center of this activity.

The appearance of Houston industrial plants is striking from the standpoint of new, modern equipment, cleanliness (natural gas used exclusively for power) and broad, well spaced layouts.

MONDAY, MAY 2

Trip M-1 — **Oil Refining**

Pan American Refining Corporation
Texas City, Texas

Pan American Refining Corporation's Texas City refinery is one of the largest and most modern in the world. Capacity is over 155,000 barrels per day of crude oil.

The tour will include stops at the Ultraformer, Alkylation Unit, Fluid Catalytic Cracking Unit, and Research & Development Center.

Trip M-2 — **Petrochemicals**

Shell Chemical Company
Houston, Texas

The Shell Chemical Houston plant manufactures organic chemicals; derived from ethylene, propylene, and butylene. Activities include production and/or purification of these olefins, and the commercial synthesis of alcohols, ketones, glycerine, and resins.

Visitors will have an opportunity to view the ethylene manufacturing and purification units, the synthetic ethyl alcohol unit, shops, control laboratories, and offices. Other parts of the plant will not be included in the tour.

Trip M-3 — **Oil Drilling Tools**

Hughes Tool Company
Houston, Texas

The Hughes Tool Company Houston plant consists of a complete metal fabricating plant including forge shop, foundry, heat treating, machine shops, pattern shop, tool and die manufacturing.

Trip M-4 — **Oil Exploration Research**

Humble Oil & Refining Co. Research Center
Houston, Texas

Humble Oil and Refining Company's Houston Research Center was completed and occupied in mid-1954. This new $3.5 million Center houses research and technical activities in the fields of oil exploration and production conducted by more than 360 employees.

Trip M-5 — **Synthetic Rubber**

Humble Oil & Refining Company
General Tire & Rubber Company
Baytown, Texas

The tour will include visits to three adjacent plants. Butyl rubber is produced at one of the Humble plants.

Butadiene, the principal ingredient in GR-S rubber, is produced at the other Humble plant

The General Tire & Rubber Company plant produces GR-S rubber.

This trip is open to United States citizens only.

Trip M-6 — **Chemicals**

Ethyl Corporation
Houston, Texas

Here are manufactured tetraethyl lead, metallic sodium, chlorine, anhydrous hydrogen chloride, ethyl chloride, and ethylene dichloride, all intermediates or components of "Ethyl" anti-knock compound.

This trip is closed to competitors of the Ethyl Corporation.

TUESDAY, MAY 3

Trip T-1 — **Oil Refining**

Shell Oil Company
Houston, Texas

Shell Oil Company's Houston refinery employs about 2,600 persons and processes approximately 130,000 barrels of crude oils per day.

The 2-hour refinery tour, by bus, will include stops at the docks, shops, wax moulding process, catalytic cracking unit and laboratory.

Trip T-2 — **Petrochemicals**

Monsanto Chemical Company
Texas City, Texas

Monsanto's styrene plant at Texas City was built by the Government in 1942 and went into operation in 1943. The plant consists of a completely integrated facility for the manufacture of styrene,

In 1947 the plant was almost completely destroyed due to the explosion of ammonium nitrate in the ship GRAND CAMP which was berthed adjacent to the styrene plant. The following year the plant was almost completely rebuilt, and since that time further expanded.

Trip T-3 — **Anhydrous Ammonia**

San Jacinto Chemical Company
Houston, Texas

The plant produces 120 tons per day of ammonia by cracking natural gas to generate hydrogen (due to contract commitments this part of the plant is not open for inspection).

Trip T-4 — **Magnesium from Sea Water**

The Dow Chemical Company, Freeport, Texas

The main portion of the tour will be an inspection of the Dow magnesium process at Plant B. Included will be a drive around the remainder of Plant B, which has approximately 700 acres "under cultivation" for production of plastic monomers, chlorinated hydrocarbons, glycols, caustic soda, magnesium, and other chemicals.

Trip T-5 — **Paper**

Champion Paper & Fibre Company
Houston, Texas

The Champion Paper & Fibre Company is a highly integrated plant which produces its own caustic and chlorine. Its daily production includes 330 ton of paper, 110 ton of paperboard, and 525 ton of pulp.

Trip T-6 — **Sugar Refining**

Imperial Sugar Company
Sugar Land, Texas

Located on the banks of lazy Oyster Creek near Houston is one of the world's most modern cane sugar refineries.

About 2,500,000 pounds of Imperial Cane Sugars are produced daily for the housewives and industries of the great Southwest.

Turbo-Topics

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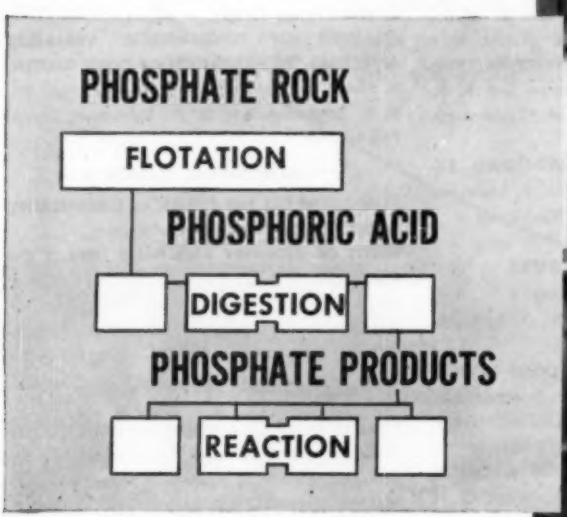

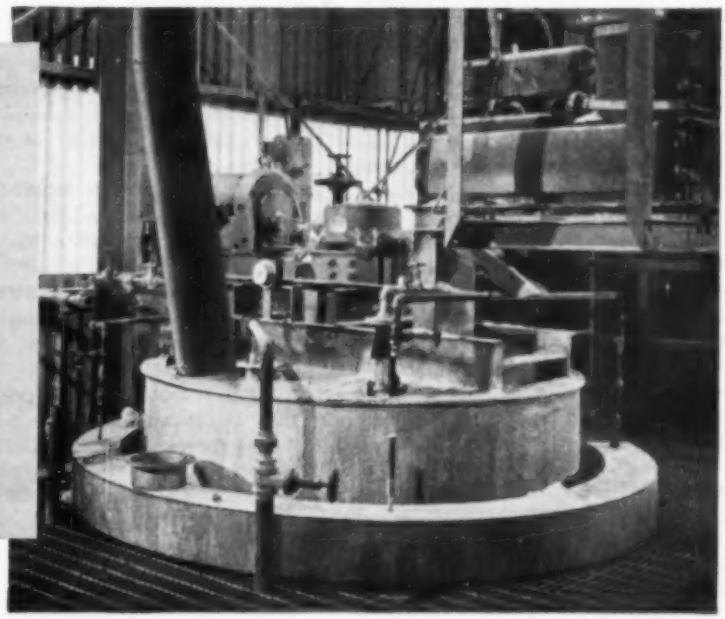

Acid Neutralizer At Phosphate Products Plant of Virginia-Carolina Chemical Corporation, Fernald, Ohio. Phosphoric acid is neutralized in the pictured Turbo-Mixer at the Fernald plant. It provides suspension and distribution of solids for uniform reaction on a Continuous-Flow basis and promotes removal of evolved gases.

production flows faster with TURBO on the job

Step by step, from beneficiation of the rock to production of finished phosphate products, Turbo-Mixers provide the controlled agitation required for maximum efficiency.

Whether you manufacture phosphoric acid, or any other chemical or metallurgical product, Turbo experience and engineering facilities can help you handle agitation problems faster, more efficiently and at lower cost. The services of a Turbo planning engineer can save valuable time for you. He's available without obligation. Write for details.

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TECHNICAL PROGRAM

Houston Meeting

► Sunday, May 1, 1955

SYMPOSIUM ON "THE PROFESSIONAL ATTITUDE" R. P. Dinsmore, Presiding.

ESSENTIAL CHARACTERISTICS OF PROFESSIONAL CONDUCT, Arthur K. Doolittle, Carbide & Carbon, South Charleston, W. Va.

THE PROFESSIONAL ATTITUDE TOWARD ONES EMPLOYER, E. F. von Wettberg, Du Pont, Newark, N. J.

THE RELATIONSHIP OF TEACHER AND STUDENT, J. H. Rushton, Illinois Institute of Technology, Chicago.

THE PROFESSIONAL ENGINEER AND THE PUBLIC, R. P. Dinsmore, Goodyear, Akron, O.

THE EMPLOYER'S ATTITUDE TOWARD PROFESSIONAL PEOPLE, L. P. Scoville, Diamond Alkali, Painesville, O.

► Monday, May 2, 1955

TECHNICAL SESSION NO. 1

SYMPOSIUM ON AZEOTROPIC AND EXTRACTIVE DISTILLATION, Dysart E. Holcomb, Presiding.

THE DEHYDRATION OF HYDRAZINE BY AZEOTROPIC DISTILLATION, R. Q. Wilson, W. H. Mink, H. P. Munger, and J. W. Clegg, Battelle, Columbus, O.

APPLICATIONS OF AZEOTROPIC AND EXTRACTIVE DISTILLATION IN THE PRODUCTION OF PETROCHEMICALS, W. C. Hopkins, Celanese, Clarkwood, Texas, and J. J. Fritsch, Celanese, Bishop, Texas.

A PRELIMINARY DYNAMIC STUDY OF FURFURAL EXTRACTIVE DISTILLATION COLUMN CONTROL, G. G. Campbell, Phillips Chemical, Borger, Texas, and D. E. Berger, Phillips Petroleum, Bartlesville, Okla.

PLANT PERFORMANCE OF A 13-FOOT DIAMETER EXTRACTIVE DISTILLATION COLUMN, J. A. Gerster, Tokuro Mizushina, Univ. of Delaware, Newark. T. N. Marks, and A. W. Catanach, Neches Butane Products Company, Port Neches, Texas.

ACTIVITY COEFFICIENTS AT INFINITE DILUTION, M. F. Gautreaux, Jr., and J. Coates, Louisiana State Univ., Baton Rouge.

CORRELATION OF BUBBLE CAP FRACTIONATING COLUMN PLATE EFFICIENCIES, E. D. Oliver and C. C. Watson, Univ. of Wisconsin, Madison.

TECHNICAL SESSION NO. 2

GENERAL TECHNICAL PROGRAM, Kenneth A. Kobe, Presiding.

KINETICS OF THE LIQUID PHASE OXIDATION OF ETHANOL, J. Klassen and R. S. Kirk, Univ. of Wisconsin, Madison.

GAS-SOLID CONTACT IN FLUIDIZED BEDS, C. Y. Shen and H. F. Johnstone, Univ. of Illinois, Urbana.

VISCOSITY OF LIQUIDS: APPLICATION OF THE THEORY OF ABSOLUTE REACTION RATES, L. F. Albright and J. Lohrenz, Univ. of Oklahoma, Norman.

A GENERALIZED CORRELATION OF DIFFUSION COEFFICIENTS. THE REDUCED DIFFUSION COEFFICIENT: ITS DEFINITION AND APPLICATION, J. R. Fair and B. J. Lerner, Univ. of Texas, Austin.

STUDIES OF THERMAL CONDUCTIVITY OF LIQUIDS. PART III, B. C. Sakiadis and J. Coates, Louisiana State Univ., Baton Rouge.

PREDICTION OF SPECIFIC HEAT OF ORGANIC LIQUIDS, B. C. Sakiadis and J. Coates, Louisiana State Univ., Baton Rouge.

TECHNICAL SESSION NO. 3

SYMPOSIUM ON DIFFERENCES IN CHEMICAL ENGINEERING THEORY—FILM THEORY, Franc A. Landee, Presiding.

MEASURED SIEVE-PLATE EFFICIENCIES COMPARED WITH VALUES PREDICTED FROM SINGLE-FILM STUDIES, F. E. Rush, Jr., and C. Stirba, Du Pont, Wilmington, Delaware.

THE ROLE OF EDDY CONDUCTIVITY IN THERMAL TRANSPORT, W. H. Corcoran and B. H. Sage, California Institute of Technology, Pasadena.

TWO FILM THEORY IN LIQUID-LIQUID EXTRACTION, N. F. Murphy and J. E. Lastovica, Virginia Polytechnic Institute, Blacksburg.

► Tuesday, May 3, 1955

TECHNICAL SESSION NO. 4

GENERAL TECHNICAL PROGRAM, D. A. Smith, Presiding.

A MODEL SYSTEM FOR TWO-SOLVENT EXTRACTION OF LUBRICATING OILS, J. Durandet and Y. Gladel, French Petroleum Institute, and T. Vermuelen, Univ. of California, Berkeley.

OPERATING CHARACTERISTICS OF A CENTRIFUGAL EXTRACTOR, F. M. Jacobsen and G. H. Beyer, Iowa State College, Ames.

LIQUID-LIQUID EXTRACTION IN A PULSED PERFORATED-PLATE COLUMN, W. H. Li and W. M. Newton, Georgia Institute of Technology, Atlanta.

GAS ABSORPTION IN BEDS OF RINGS AND SADDLES, Max Leva, Consultant, Pittsburgh, Pa.

RATE OF FLOW AND MECHANICS OF BUBBLE FORMATION FROM SINGLE SUBMERGED ORIFICES, I. Leibson, E. G. Holcomb, J. J. Jacmic, and A. G. Cacoso, U. S. Army Chemical Corps, Camp Detrick, Md.

TECHNICAL SESSION NO. 5

SYMPOSIUM ON THE FLOW OF FLUIDS THROUGH POROUS MEDIA, L. P. Whorton, Presiding.

AN ENLARGEMENT TECHNIQUE FOR THE SEMI-MICROSCOPIC STUDY OF FLUID FLOW AND PHASE DISTRIBUTION IN POROUS MEDIA, O. K. Kimbler and B. H. Caudle, Atlantic Refining, Dallas, Texas.

THE EVOLUTION OF GAS FROM LIQUIDS FLOWING THROUGH POROUS MEDIA, E. B. Hunt and V. J. Berry, Stanolind Oil & Gas, Dallas, Texas.

THE DETERMINATION OF RELATIVE PERMEABILITY UNDER SIMULATED RESERVOIR CONDITIONS, J. W. Wilson, Union Oil of California, Brea.

NUMERICAL SOLUTION OF TWO-DIMENSIONAL HEAT FLOW PROBLEMS, J. Douglas, Jr., and D. W. Peaceman, Humble Oil & Refining, Houston, Texas.

TECHNICAL SESSION NO. 6

SYMPOSIUM ON THE FLOW OF FLUIDS THROUGH POROUS MEDIA, Henry H. Rachford, Jr., Presiding.

FLUID FLOW IN FRACTURES, J. L. Huitt, Magnolia Petroleum, Dallas, Texas.

ON THE MECHANICS OF STEADY-STATE SINGLE PHASE FLUID DISPLACEMENT FROM POROUS MEDIA, D. U. von Rosenberg, Humble Oil & Refining, Houston, Texas.

CORRELATION OF DYNAMIC HOLDUP IN POROUS MEDIA, J. L. Reeves and D. Cornell, Univ. of Texas, Austin.

ANALYSIS OF FUNDAMENTAL VARIABLES AFFECTING THE FILTRATION OF CORN GLUTEN, B. Martin, Corn Products Refining, Argo, Ill., B. A. Schepman and D. A. Dahlstrom, Eimco, Palatine, Ill.

NON-TECHNICAL SESSION A

SYMPOSIUM ON THE CHEMICAL ENGINEERING CURRICULUM, J. W. Mason, Presiding.

NEEDS OF INDUSTRY AND THEIR IMPACT ON CURRICULUM, C. M. Cooper, Du Pont, Wilmington, Delaware.

BASIC OBJECTIVES IN ENGINEERING EDUCATION FROM THE GENERAL MANAGEMENT VIEWPOINT, C. E. Reed, General Electric, Waterford, N. Y.

DEVELOPMENT OF A CHEMICAL ENGINEERING CURRICULUM, F. M. Tiller, Dean of Engineering, Lamar State College, Beaumont, Texas.

SCIENCE ENGINEERING AND CHEMICAL ENGINEERING, R. R. White, Univ. of Michigan, Ann Arbor.

► Wednesday, May 4, 1955

TECHNICAL SESSION NO. 7

GENERAL TECHNICAL PROGRAM, R. H. Price, Presiding.

SURFACE TENSION AND THE PRINCIPLE OF CORRESPONDING STATES, J. R. Brock and R. B. Bird, Univ. of Wisconsin, Madison.

HARD SURFACING IN PROCESS INDUSTRIES, W. L. Lutes and H. F. Reid, The McKay Co., Pittsburgh, Pa.

THE EFFECT OF LIQUID HYDROCARBONS AND AQUEOUS GLYCOL SOLUTIONS ON HYDRATE FORMATION, F. R. Scauzillo, Magnolia Petroleum, Dallas, Texas.

HIGH TEMPERATURE HEATER DESIGN AND RADIANT TRANSFER IN HEATERS AND BOILERS, L. J. McCarthy, Chemical Construction Corp., New York.

A NEW PROCESS FOR THE RECOVERY OF JUICE FROM SUGAR BEETS BY RUPTURE OF THE BEET CELLS, L. E. Brownell, S. A. Zieminski, and T. H. Lee, Fission Products Laboratory, Univ. of Michigan, Ann Arbor.

EXPERIENCES WITH THE MIXED-BED DEIONIZATION OF WATER, G. P. Monet, Du Pont, Wilmington, Delaware.

(Continued on page 70)

Easy working and long life in chemical atmospheres ...for the Lapp Valve

Non-ferrous working parts in the Lapp Valve eliminate freeze-ups from scales of corrosion. Threaded stud, yoke bushing and nuts, and plug cap are all brass or bronze, which keep the valve smoothly operative in all but the most unusual conditions of chemical atmosphere. Flange, yoke and gland are of high strength malleable or ductile iron, and are protected with baked-on Epon-base acid-proof paint. Flanges are permanently bonded to porcelain or armor with acid-proof resin cement. *Write for bulletin with complete description, characteristics, and specifications. Lapp Insulator Co., Inc., Process Equipment Division, 460 Wendell Street, LeRoy, New York.*

Y-valves, angle valves, flush valves, safety valves, and plug cocks of Lapp Porcelain have standard bolt-circle flanges for easy connection to all piping and equipment.

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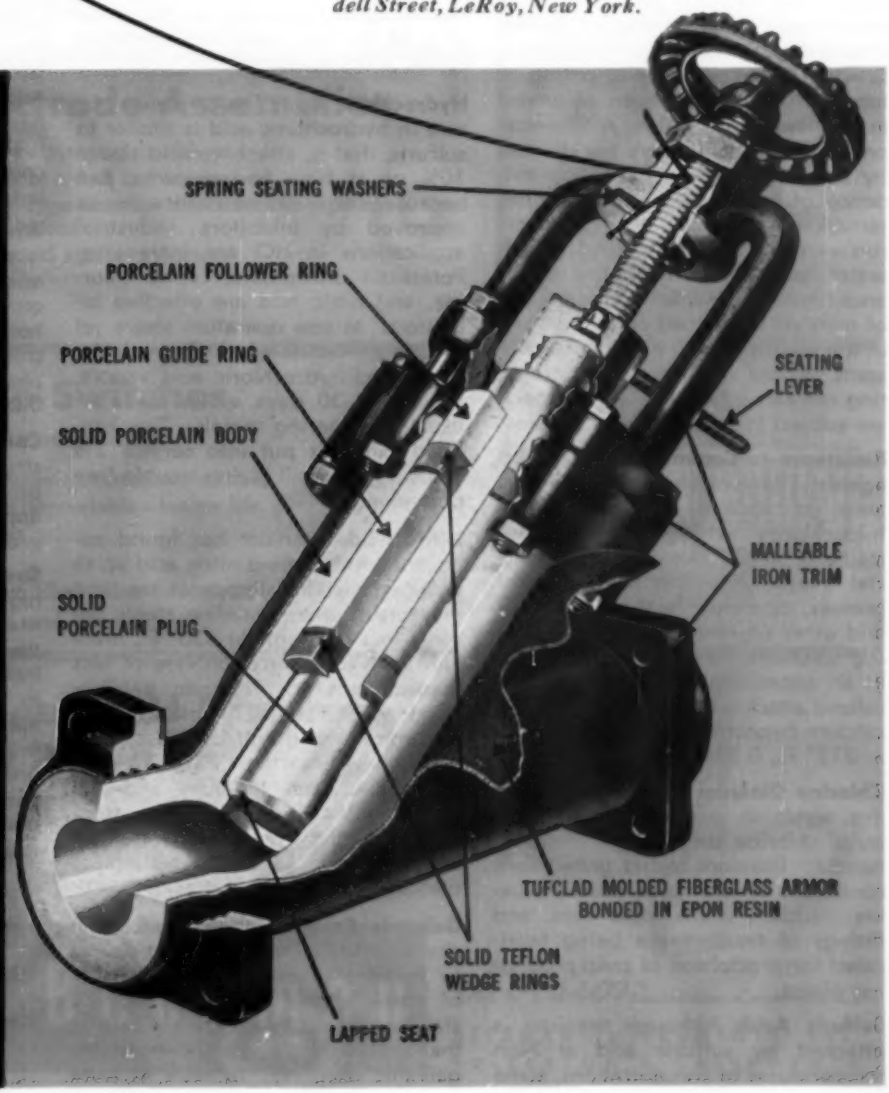

TITANIUM REFERENCE SHEET
(Part 2)

G. E. Hutchinson assistant sales manager, Rem-Cru Titanium, Inc., Midland, Pa.

The scope of Part 2 (see Part 1, C.E.P., March, 1955, p. 34) is to indicate the type of applications which will be of immediate interest to the chemical engineer. These will be restricted to examples where titanium can offer outstanding improvements in service life, reduced maintenance, elimination of downtime, or allow the processing temperatures to be increased to provide substantial economies.

Sea Water & Marine Atmospheres: Titanium's resistance to corrosion and marine environments is widely known. Corrosion samples, exposed at the International Nickel testing site at Kure Beach, N. C., showed a corrosion rate of 0.0008 mils/yr. (0.0000008 in./yr.). At this rate, it would take 1,250 years to reduce the thickness of a titanium sheet 0.001. In addition, no evidence of pitting or localized attack has been observed in titanium in sea water. Mechanical properties of titanium are not affected by sea-water, nor is there any evidence of stress-corrosion. A rather remarkable fact is that fatigue tests run with samples immersed in salt water have shown the same endurance limit as those run in dry air. Use of titanium is justified on a cost basis in the marine industry in key trouble spots, where slight corrosion or pitting can cause failure or where parts are subject to severe stress corrosion.

Resistance to Commercial Bleach Reagents: Titanium shows good resistance to sodium and calcium hypochlorite which rapidly attack stainless steels, aluminum, and special alloys. Titanium is in use for presses, screens, heat exchangers, and other equipment. Hot and boiling solutions do not attack titanium at an appreciable rate, nor does localized attack occur. Corrosion rate in calcium hypochlorite at 95° F. is nil; at 212° F., 0.05 mils penetration/yr.

Chlorine Dioxide: Used as a bleaching agent in processing of paper pulp, chlorine dioxide is difficult to handle. Titanium tested under field conditions shows no corrosion. Mixers, paddles, shafts, pipe lines, and fittings of titanium are being fabricated for production of pulp-processing plants.

Sulfuric Acid: Although titanium is attacked by sulfuric acid at high temperatures or concentrations, some of the important corrosion applications of titanium are in sulfuric acid solutions. Sulfuric acid up to 5% does not corrode titanium, but 20 to 50% sulfuric acid will, under ordinary conditions, attack titanium rapidly. However, the corrosion picture is drastically changed by the presence of inhibitors. For example, ½ to 3% nitric acid in a warm, 50% sulfuric acid solution reduced corrosion rates to a negligible 2 mils/yr. When titanium is the anode in an electrolytic cell, corrosion resistance to sulfuric acid is increased. Thus, titanium finds wide industrial use in chemical ore refining, in electroplating racks, and in anodizing racks. When used as anodizing racks, not only does titanium resist corrosion, but the stripping of the rack between operating cycles is unnecessary.

Hydrochloric Acid: The corrosion picture in hydrochloric acid is similar to sulfuric; that is, attack is rapid above 10% or at high temperatures, but because corrosion resistance is so improved by inhibitors, industrial applications in HCl are increasing. Potassium dichromate, cupric chloride, and nitric acid are effective inhibitors. In one operation steam jet diffusers, handling high velocity steam and hydrochloric acid vapors, lasted for 30 days when made of usual engineering metals. Titanium-lined diffusers put into service 2½ years ago are still giving trouble-free operation.

Nitric Acid: Titanium has found application in handling nitric acid up to 65% at elevated temperatures and pressures, where stainless steels become less resistant. At 330° F., titanium showed a corrosion rate of less than 5 mils/yr. Titanium exhibits good resistance to corrosion in all concentrations of nitric acid. However, violent reactions have been reported between titanium and red fuming nitric acid. For this reason, optimum safety precautions are recommended in corrosion testing of titanium in fuming nitric acid.

Galvanic Couple Tests: A desirable characteristic of titanium is its ability to polarize readily to the potential of more anodic materials such as stainless steel. In no known case is the attack of titanium increased by galvanic coupling. In tests at Kure Beach in sea water stainless steel and Inconel showed no increase in corrosion by coupling with titanium. However, aluminum alloys increased their corrosion rate by factors of 3 to 10 times when coupled. Magnesium, copper, silver, and monel also were attacked 1½ to 3½ times faster when tested as galvanic couples with titanium. This indicates that titanium may be used in service adjacent to stainless or Inconel, but precautions should be taken to insulate titanium and aluminum, copper, or silver base alloys if they are used together in structural applications.

Other Corrosion Applications: Titanium shows excellent resistance to wet chlorine, (containing 0.013% or more water vapor), to hot metallic chlorides, sulfur dioxide and molten sulfur. Acetic acid and most fatty acids do not affect titanium. Titanium has been successfully tested in virtually all corrosive solutions encountered in the food processing industries.

Where Titanium is Attacked: Titanium is rapidly corroded by hydrofluoric acid. Generally, titanium is not recommended in high concentrations of hot reducing acids, such as hydrochloric, sulfuric, oxalic, formic, or phosphoric. Dry chlorine (less than 0.05% water) will attack titanium.

Corrosion Resistance of Alloys: High-strength titanium-base alloys now in production for the aircraft industry appear to have the same corrosion properties as titanium itself.

Strength-Weight Applications: The high strength-to-weight properties of titanium alloys, which account for their extensive use in the aircraft industry, may also be of importance to the chemical engineer in certain applications. A high-speed centrifuge is an example of this type of application. Naturally, high strength-to-weight is a secondary advantage in many applications in the chemical industry.

CORRECTION

In March issue under Physical Properties the words Electrical resistivity were inadvertently omitted before 370 ohms/cir. mil ft.

No. 44

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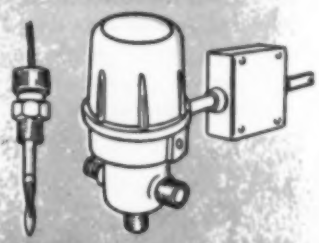

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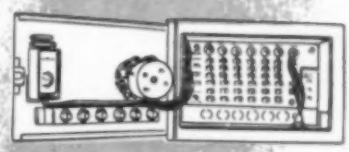

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Write for data file 53—35

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Left—TV: Rocket Expert R. A. Cooley (Olin Mathieson) interviewed by Mary Snow Ethridge, *Small Talk*, WHAS-TV.

Center—Auctioneer G. W. Packowski (Ent. Comm. Ch.) disposes of merchandise to "horserace" winners of play money.

Right—Banquet.

LOUISVILLE | MEETING REPORT

- **PANEL—of industrial relations experts termed unionization incongruous with professionalism . . . conceded that if enough want it management would reluctantly go along . . .**
- **DODGE—as president of A.I.Ch.E. announced new-member drive . . . prospect of dues increase . . . p. 48**
- **ETHRIDGE—at banquet, called German comeback an "Economic Miracle" aided by same sort of priming Washington uses at home . . .**
- **TV—interviewed rocket expert Cooley who predicted artificial satellite within own lifetime . . .**
- **VITAL STATISTICS—Total there about 1,200 . . . Exclusive C.E.P. survey shows attendance from far and wide, plus spread of occupations . . . p. 46**

A blustery Louisville extended a warm, but indoor welcome to the chemical engineering profession during the early Spring (?) meeting March 20-23. A total of 48 papers were given, best job of presentation being by D. B. Metzner, U. of Delaware.

The Heat Transfer Symposium, co-sponsored by the A.S.M.E. drew a surprisingly heavy attendance of mechanical engineers, a survey of registration cards by C.E.P. revealed.

INDUSTRIAL RELATIONS—*definitely human*

One of the outstanding events was the Industrial Relations Symposium—Tuesday afternoon's exclusive indoor event. Kick-off for the session was a "buzz luncheon," which turned out to be patterned after the old time "sewing circle" when, partly through lunch, the moderator of the affair (Guy B. Arthur, Guy B. Arthur and Associates, Toccoa, Ga.—an employee opinion survey firm) designated one at each table to act as "captain" of discussion. Each captain was asked to accumulate a list of questions to be put before panel in written form. About 1:30, all cards were collected, and everyone was asked to be back by 2:00. By this time, the room was filled. According to one observer, he saw no one leave the large room—occupied by around 400—until almost 4:00, the time the meeting was brought to a close.

D. C. Scheline (Gulf Res. & Devel., Pittsburgh) and R. D. Sheeline (U. S. Navy, Washington).

On the firing line to give their answers were panelists: R. F. McCoole, technical personnel manager, Monsanto; T. W. Collins, general personnel director, Pittsburgh Plate Glass; John Post, manager of industrial relations, Continental Oil.

Here is a summary of questions, and general sense of the panel member's discussion relating to them . . .

Q. Unionism? A. Can't be ignored. Some form of collective bargaining may possibly evolve. Unionism in general, however, seems incongruous with professionalism. Best preventive agent is improved communications (research men, for example, want to know something about success marketing department has with products, management s intentions about expansions or diversification, etc.). However, if a sizeable group of people give consistent evidence of wishing to bargain as a group rather than as individuals, management may go along and accede to their wishes. Professional licensing is not an important preventive measure.

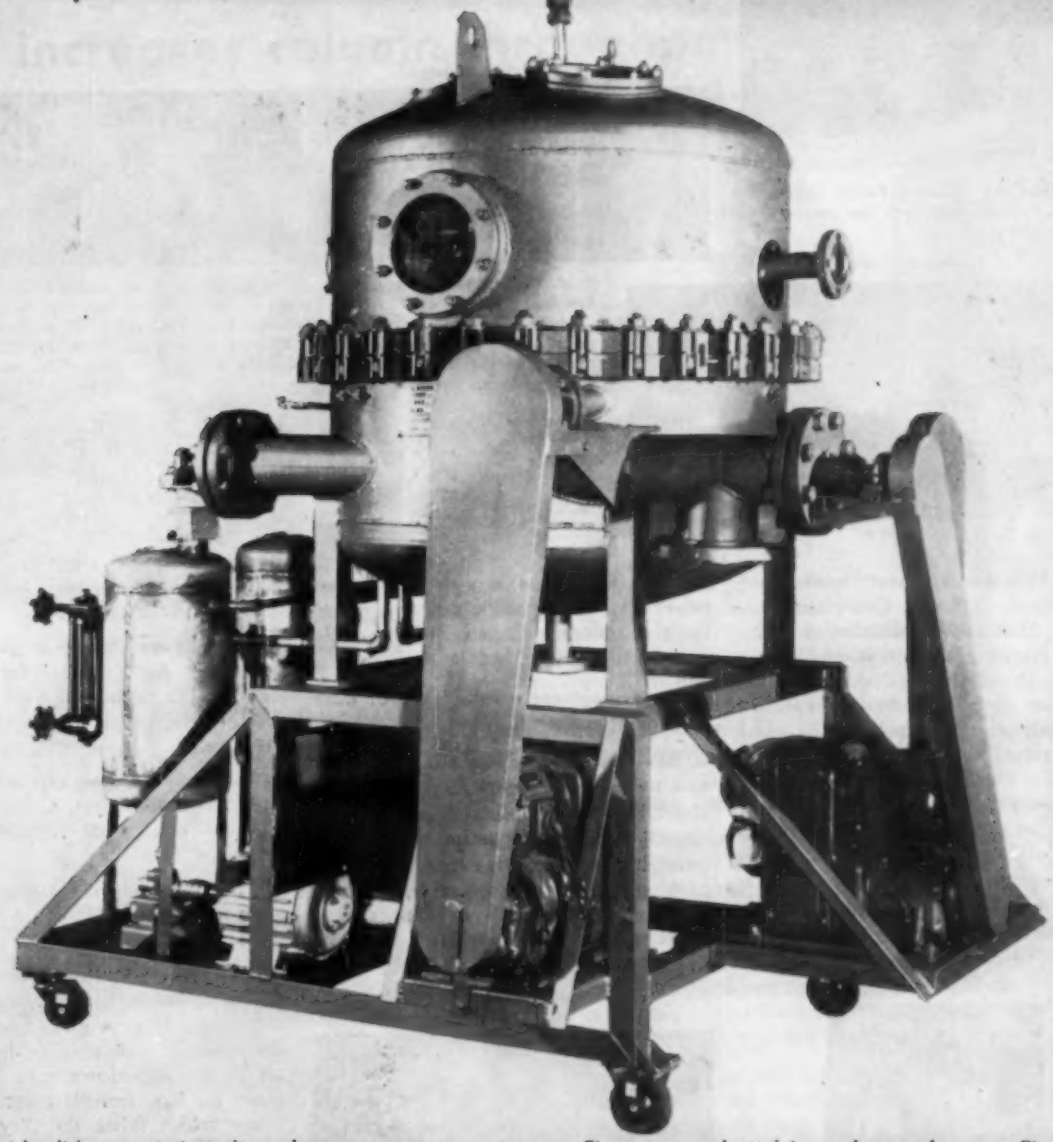
Q. Shortage of engineers? A. Real. Primarily qualitative, however. Everyone wants the better men. Competition for this year's graduates higher than last. Some firms have tried substituting non-engineers on jobs formerly filled exclusively with engineers, but management still wants engineers.

Q. Salaries? A. Beginners' spiralling starting salaries shrinking differential with older men—making a problem. Supply vs. demand situation is definitely in control.

Q. Job evaluation—does it work? A. Yes, and it's not too difficult to do. Job worth can be determined by rating: requirements of job, its importance, and difficulty in accomplishing. Research jobs are hardest to evaluate; bonus-payment in event of accomplishment one workable solution.

Council in Louisville session: l. to r.—G. E. Holbrook, W. A. Cunningham, W. L. Faith, W. E. Lobo, A. K. Doolittle, F. J. Van Antwerpen, B. F. Dodge, G. G. Brown, W. R. Dixon, L. Van Horn, E. B. Chiswell, Jr., D. L. Katz, S. Sheerin (Mrs.)

Complete Continuous Pressure Filter Station



Liquid-solids separation through a pressure-vacuum differential has many applications in chemical processing.

Eimco designed, tested and approved pressure vessels of this type have found wide acceptance in many different kinds of jobs. Some of these use heat and others use inert gas. Some of the jobs involved combustible materials and others non-combustibles.

All of the installations are classified as far as Eimco is concerned to protect the customer's process or his idea and his flow sheet.

Eimco was selected in each case because Eimco's experience in the field of filtration is unsurpassed and Eimco's ability to engineer into each filter that extra quality that provides for greater product recovery and greater profits for the user.

Let Eimco's Research and Development Center tackle your filtration problem. You will have the benefit of work by some of the best technologists in the industry, plus complete pilot plant data. Eimco backs the recommendations of its Research Center by a guaranteed performance.

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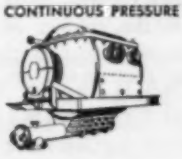
B-103

BURWELL

CONTINUOUS PRESSURE



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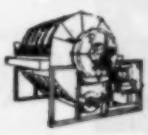


BI-CARB

PRESSURE PRECOAT

PAN

Top—Industrial Relations Panel: Collins, Arthur, Post, McCoole, with Ray Dinsmore and Art Doolittle.

Bottom—"Get acquainted" party.

T. W. Collins, gen'l personnel dir., Pittsburgh Plate Glass—Indus. Relations Sympos., President of A.I.Ch.E.; Barnett F. Dodge; John Post, mgr. indus. relations, Continental Oil Co.—Indus. Relations Sympos.; R. F. McCoole, tech. pers. mgr., Monsanto—Indus. Relations Sympos.; Mark Ethridge, banquet speaker; Guy B. Arthur, pres., Guy B. Arthur & Assoc.—Chairman, Indus. Relations Sympos.

Q. What about personal evaluation? A. Extremely difficult. Consensus was, however, that such evaluation done by persons knowing the situation by long contact with individual is better accepted than when done by outside "experts." Most frustrating problem: How to counsel individual having "getting along" problems. Formal, frequent, counselling sessions may be the answer. Objective is to let *each* person know regularly how he's doing. Reaction has been good, an employee appreciates attention given him. Counselling training is being given supervisors in some firms, with good results.

Q. What is a good way to get a pay raise? A. Train one's self, then sell one's competence in field, loyalty, willingness to produce, etc.

Q. Is the engineer usually good at this? A. Not at selling himself.

Q. Does industry have a fair wage pattern for technical men? A. As indicated above, industry has lots of problems in comparatively rating technical jobs and technical people. However, this is improving. Among the incentives believed genuinely worthwhile are stock purchase plans and partial-subsidy for those seeking advanced training.

Q. Should new engineer be started at line or staff? A. Line.

Q. Should young engineer generalize or specialize? A. Specialize for a while—long enough to make a good showing—then start generalizing to broaden experience.

Q. Have recent company mergers hurt engineering staffs? A. Generally speaking, no—perhaps because of shortage of engineers.

Q. What do engineering employees complain most about? A. Poor communications.

Q. What is major problem about communications? A. That each person pictures himself as a good communicator, and doesn't realize when he's holding up the flow of information. His fellows down the line feel "left out" about not being told. What do they then do? Sit back and feel vexed about the situation.

Q. What is principal role of an industrial relations department? A. To help management think through their personnel problems.

Top left, l. to r.—E. D. Unger, Ch., Comm. on Arrangements, R. M. Reed, Ch., Tech. Program Comm.

Bottom—G. J. Schaaf, Ch. Publicity Comm.; W. M. Glenn, Ch. Louisville A.I. Ch.E. Section; Mrs. Glenn; Mrs. Linak; T. R. Linak, Ch. Hotel & Meeting Rooms Comm.

Top right, l. to r.—G. C. Williams, Sec'y., General Comm., Mrs. Williams, W. M. Gaylord, Jr., S. C. Spalding.

GERMAN COMEBACK

Mark Ethridge, publisher of Louisville's two newspapers,* is back once again from a session in Europe for the U. S. State Department.

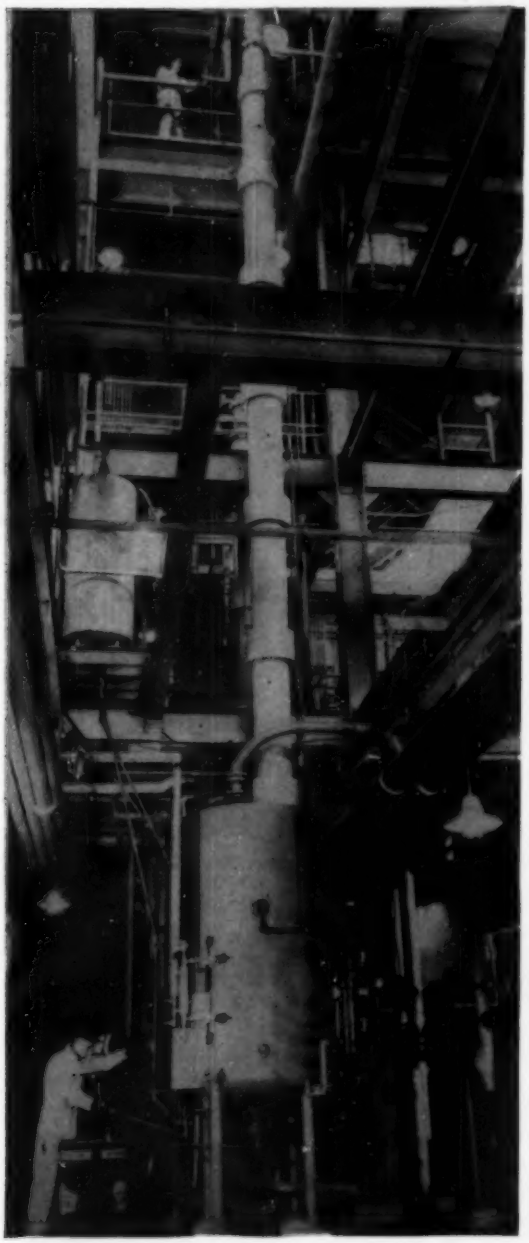
The meeting was fortunate to have Ethridge as its banquet speaker, not only because he is versed at first hand on the subject of Germany, but also because he is a thoroughly captivating speaker.

* The Courier-Journal and The Louisville Times.

(*Continued on page* 46)

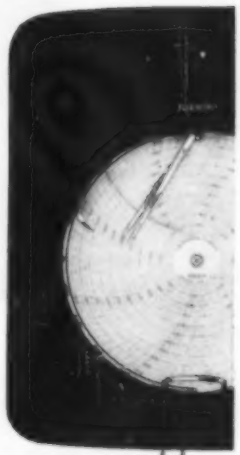
DOW CORNING

increases column throughput without impairing overhead purity



Heat input to the still of this vacuum packed fractionating column in Dow Corning pilot plant is under precise Foxboro Control. Based on pressure drop across column, Foxboro Control maintains optimum conditions at all times See diagram.

...with Foxboro Control of pressure drop



Maximum column loading with minimum priming or carry-over is one outstanding efficiency feature of Dow Corning Corporation's pilot plant production of chlorosilanes and silicones at Midland, Mich. To achieve this optimum throughput, completely unaffected by variations in product concentration, Dow chemists employed the Foxboro Pressure Drop Method of Control.

In this automatic Foxboro System, a d/p Cell Transmitter continuously measures column pressure loss caused by plate or packing resistance plus liquid and vapor mass velocities. This *true* measure of vapor product movement is relayed by the transmitter to a Foxboro M/40 Controller. The Controller precisely regulates heat input to the column . . . maintains steady boil-up for any given feed stock, without overloading.

Foxboro Pressure Drop Control will perform with the same high-efficiency on *your* column . . . whether it's packed, bubble cap, or sieve-plate type . . . on continuous or batch runs. For complete details, write for Engineering Data Sheet 282-14.

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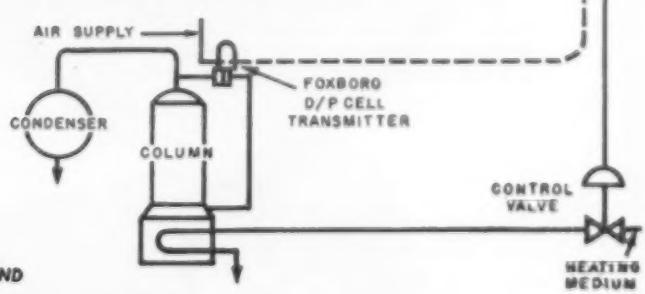

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

FOXBORO
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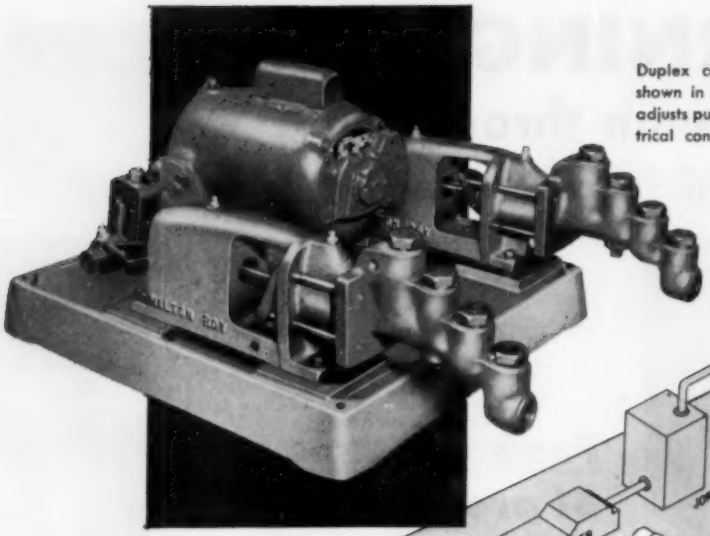
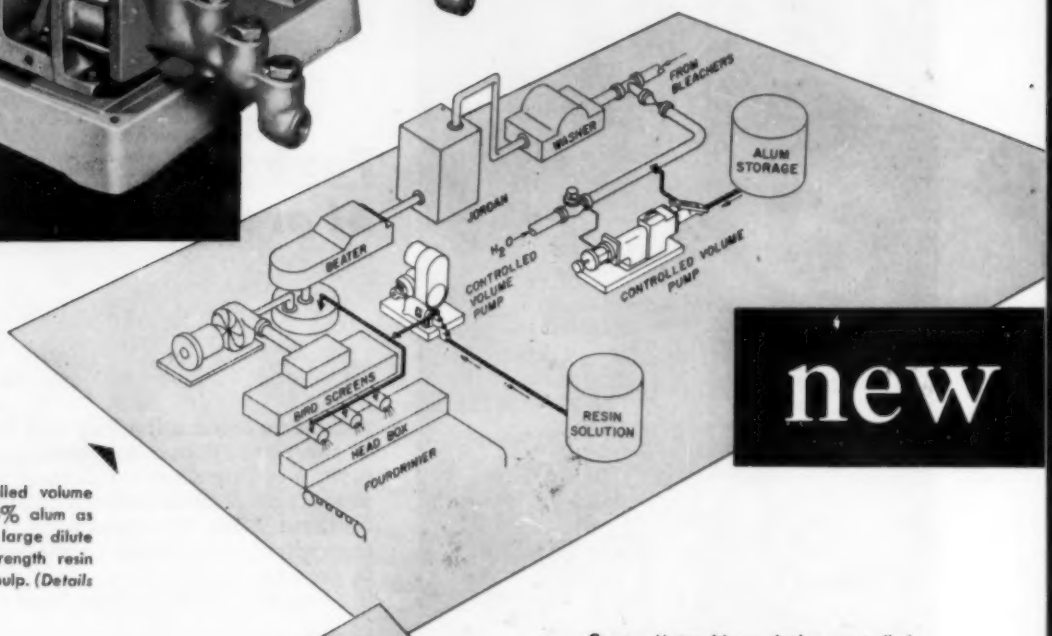
automatic control for fractionating column pressure-drop

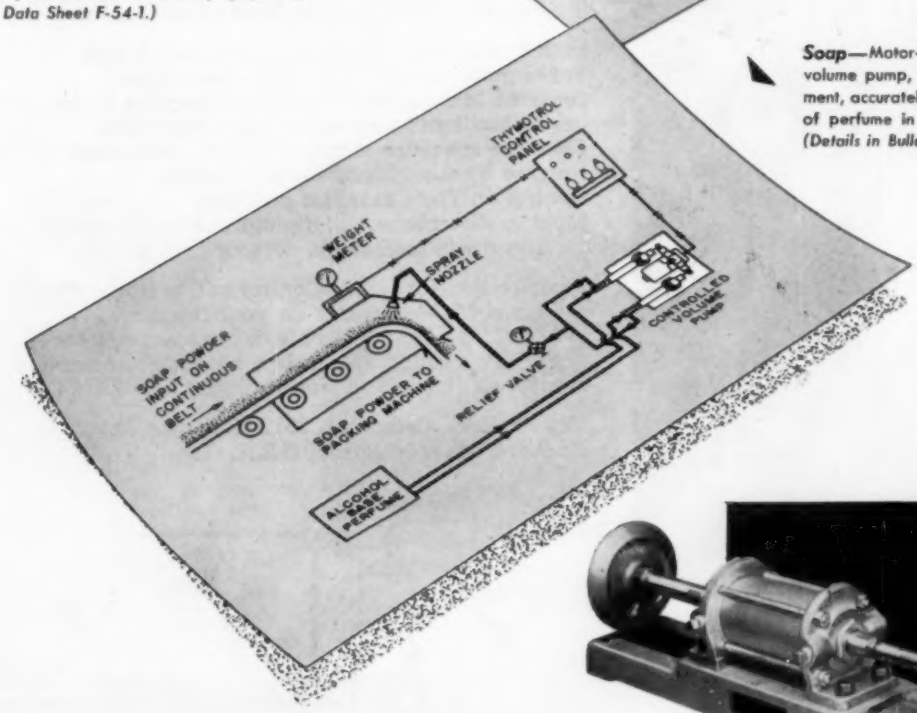


Duplex controlled volume pump. Model shown in perfume addition automatically adjusts pumping speed in response to electrical control signal from weight meter.

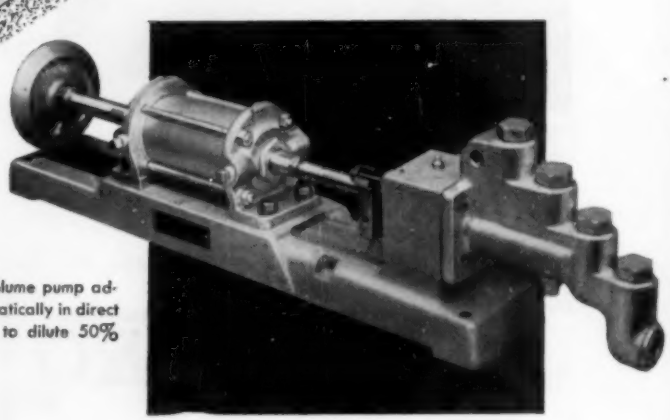


new

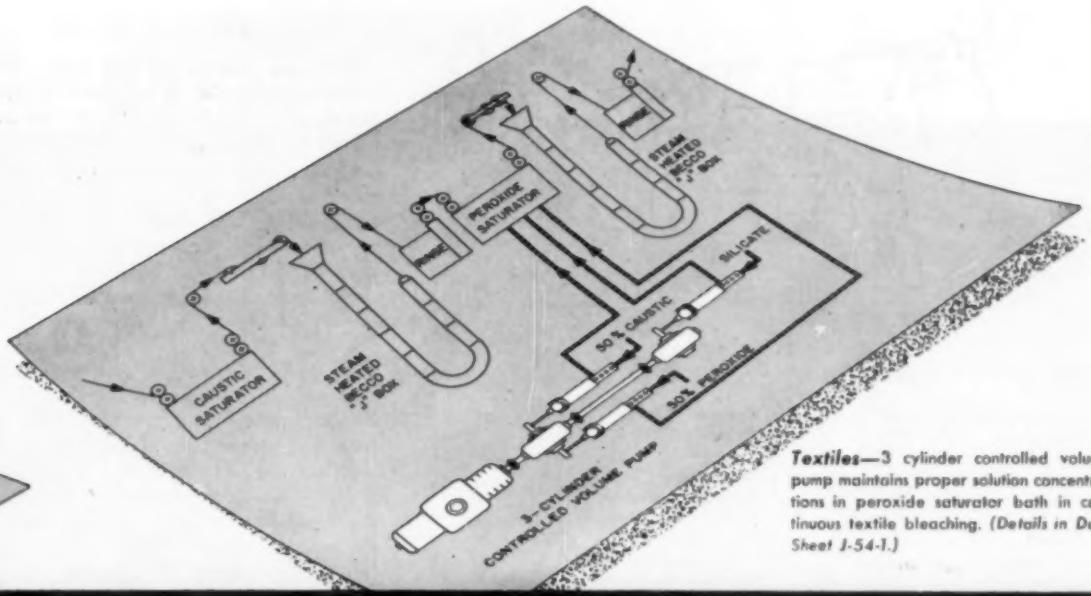
Paper—Air-operated controlled volume pump continuously dilutes 50% alum as needed, eliminating need for large dilute alum storage tanks. Wet strength resin pump controls flow of resin to pulp. *(Details in Data Sheet F-54-1.)*



Soap—Motor-driven duplex controlled volume pump, acting as final control element, accurately meters low-capacity flow of perfume in accordance with demand. *(Details in Bulletin 1253.)*



Air-operated controlled volume pump adjusts pumping speed automatically in direct proportion to water flow to dilute 50% alum.



Textiles—3 cylinder controlled volume pump maintains proper solution concentrations in peroxide saturator bath in continuous textile bleaching. *(Details in Data Sheet J-54-1.)*

flow-control approach

cuts chemical costs...guards product quality... accurately meters odorants, corrosion inhibitors, filter aids, detergents, defoamers, dyes and other process additives

Controlled volume pumps are flow control instruments

PRECISION metering of additives and other process fluids is very often the key to close quality control and significant savings on chemical costs. In many critical processes, Milton Roy *controlled volume pumps* are being used to excellent advantage as high-accuracy *flow controllers*, *ratio controllers*, and *final control elements* in the control loop.

Controlled volume pumps are actually flow control instruments . . . particularly valuable for handling low-capacity flows. Reciprocating, positive displacement type pumps, they precisely meter process additives within 1% accuracy! Pumps are available in capacities up to 1350 gallons per hour . . . pressures up to 50,000 pounds per square inch . . . with manual or automatic speed and stroke adjustment.

Typical applications are shown here. How can you profit by using controlled volume pumps in your process? Milton Roy offers you long experience in handling low-capacity flow control problems . . . in engineering complete chemical feed and automatic control systems. For details, write for the *Data Sheets* listed and other technical information. Or, send your problem to the Milton Roy Company, *Manufacturing Engineers*, 1300 East Mermaid Lane, Philadelphia 18, Pa.

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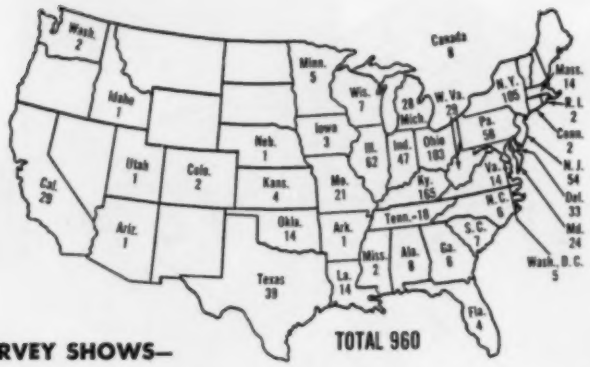
LOUISVILLE REPORT

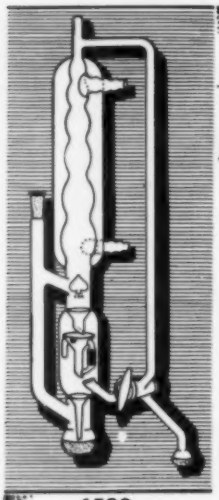
where they came from



EXCLUSIVE CEP SURVEY SHOWS—

what they do

			%
Engr'g, Chemical & Other			
Chem. engr.	228		
Engr.	7		
Mech. engr.	25		
Chemist	11		
Metallurgist	1		
Technologist	5	277	29.0
Prod'n, Process Dsgn, Devlp't			
Design engr.	22		
Process engr.	47		
Devel. engr.	85		
Res. engr.	77		
Nucl. engr.	15		
Control engr.	7		
Planning engr.	1	254	26.6
Admin. & Tech. Suprv'n			
Corp. executives	16		
Chief engr.	38		
Project engr.	58		
Plant oper'ns mgr.	49		
Plant oper'ns engr.	23		
General mgr.	8		
Personnel director	4		
Manager	12	208	21.8
Consulting			
Consultant, teaching	77		
Consultant, non-teaching	10		
Technical director	5		
Editor	6	98	10.3
Marketing			
Sales engrs.	39		
Product applic'ns or field engrs.	16		
Public relations	1		
Marketing aspects	6	62	6.5
Miscellaneous			
Student chem. engrs.	21		
Chem. engrs. in armed forces	3		
Retired chem. engrs.	1	25	2.6
Unclassified			
No classific'ns specified..	30	30	3.1



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This magnetic head provides a reproducible semi-automatic reflux ratio control. The ratio from "off" to "on" time is the reflux ratio which is set on a time basis. Therefore, constant, regardless of through-put except at low volumes, when a single drop becomes a significant quantity.

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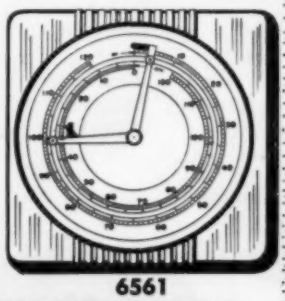

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A superior timing mechanism with independent cycles with a maximum take-off and reflux time of 120 seconds. Minimum setting ½ second. Complete with operating and maintenance instructions.

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(*Continued from page 42*)

Principal themes of his talk: The "economic miracle" of a recovered Germany, and the "calculated risk" we are taking in rearming the country.

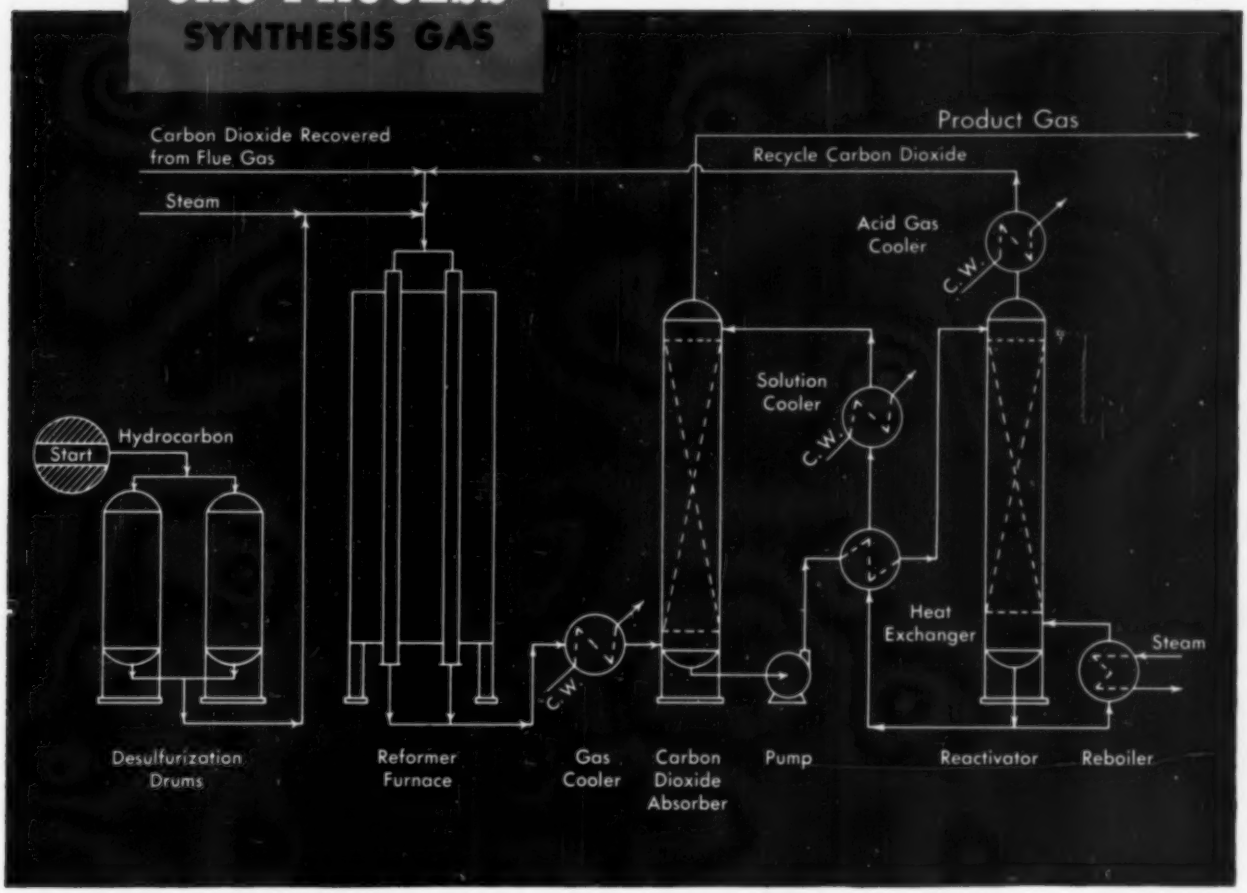
Germany is producing more goods today than she did in 1936, according to Ethridge. She is doing this because of an amazing recovery from the ravages of a total war. As to how this came about, Ethridge cited the following as having played major parts: By being a loser at war she had no major debt to reduce after the shooting stopped. $3 billion in Marshall plan aid has provided the needed financial base for operations. A rapid write-off law has encouraged capital investment. Other laws have favored real estate development. Also, management has had a virtual no-strike agreement with labor, which earns an average of $22 for a 50-hour week, in contrast to $28 for 40 hours paid in England. Last but not least, Ethridge credited German businessmen as "go-getters."

Unconditional surrender has proved to be a correct policy, believes Ethridge, —it brought home to a whole people the disaster of a major war brought on by their own actions. It has resulted in a sharp break between the old Hitler regime and the people, apparently between the general staff and the people as well. The general staff, Ethridge added, has never won a war and the people seem impressed at last by that poor record.

Ethridge terms the German rearmament, "the most reluctant rearming, I think, in the history of the whole world." This seems to be based largely a great pacifist movement among the German people, particularly stirred by the women. But once rearmed, will the people remain pacifist, or revert to the ambitions that have been successful in the past in luring them back into the general staff concept? Ethridge doesn't know. It seems we are involved in an experiment for which there is no direct historical precedent.

l. to r.—J. C. Reed, A. B. Metzner (winner of best presentation award), R. W. Reed (Sympos. Ch.), M. B. Glasser, R. S. Montgomery.

OXO PROCESS
SYNTHESIS GAS



GIRDLER hydrogen-carbon monoxide plants give wide range of mixtures

THE FLOW CHART shows the design of a plant for producing synthesis gas for the "Oxo Process" used in the production of aldehydes and high molecular weight alcohols. A wide range of compositions is obtainable with Girdler synthesis gas plants . . . the ratio of hydrogen to carbon monoxide can vary from 4:1 to 1:9, to suit your requirements.

Girdler assumes complete responsibility for all phases of design, engineering and construction of these plants. Why not take advantage of Girdler's experience for *your* processing facilities. Call the nearest Girdler office.

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Ammonia Plants
Ammonium Nitrate Plants
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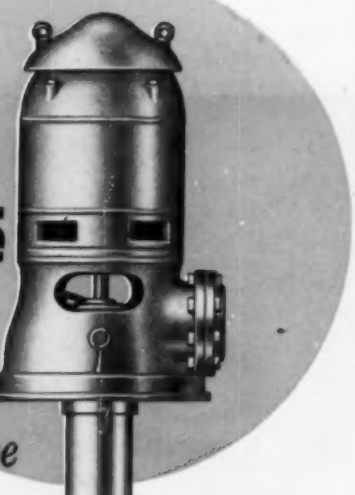
Verti-Line PUMPS

are backed by 47 years of experience



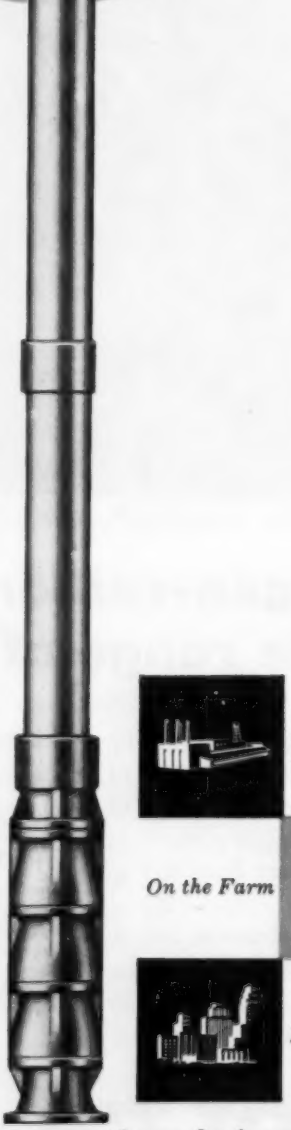
Verti-Line Turbine Pumps are the result of almost half a century of experience in pump research, design, engineering, manufacturing.

Designed and engineered into every Verti-Line Pump are feature after feature that have been proven in-the-field to give better balanced performance and efficiency.

The highest standards of manufacturing quality-control in the turbine pump industry guarantee that Verti-Line Pumps are made to last longer, operating under the toughest conditions.

More than 100,000 satisfied vertical pump users agree there's no pump like Verti-Line for low first cost, economical operation, and negligible maintenance.

Whatever your vertical pump needs — investigate Verti-Line before you buy.



In All Industry

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State of the Institute

Remarks by President Barnett F. Dodge made at the banquet of the Louisville National Meeting, March 22, 1955.

I would like to tell you something about the current problems and some of the recent developments in the Institute.

First—about nuclear energy. This is a very great and growing field—it is something which many expect will be of tremendous importance in the next five or ten years. I refer not to atom bombs but to peaceful uses of nuclear energy, particularly nuclear power.

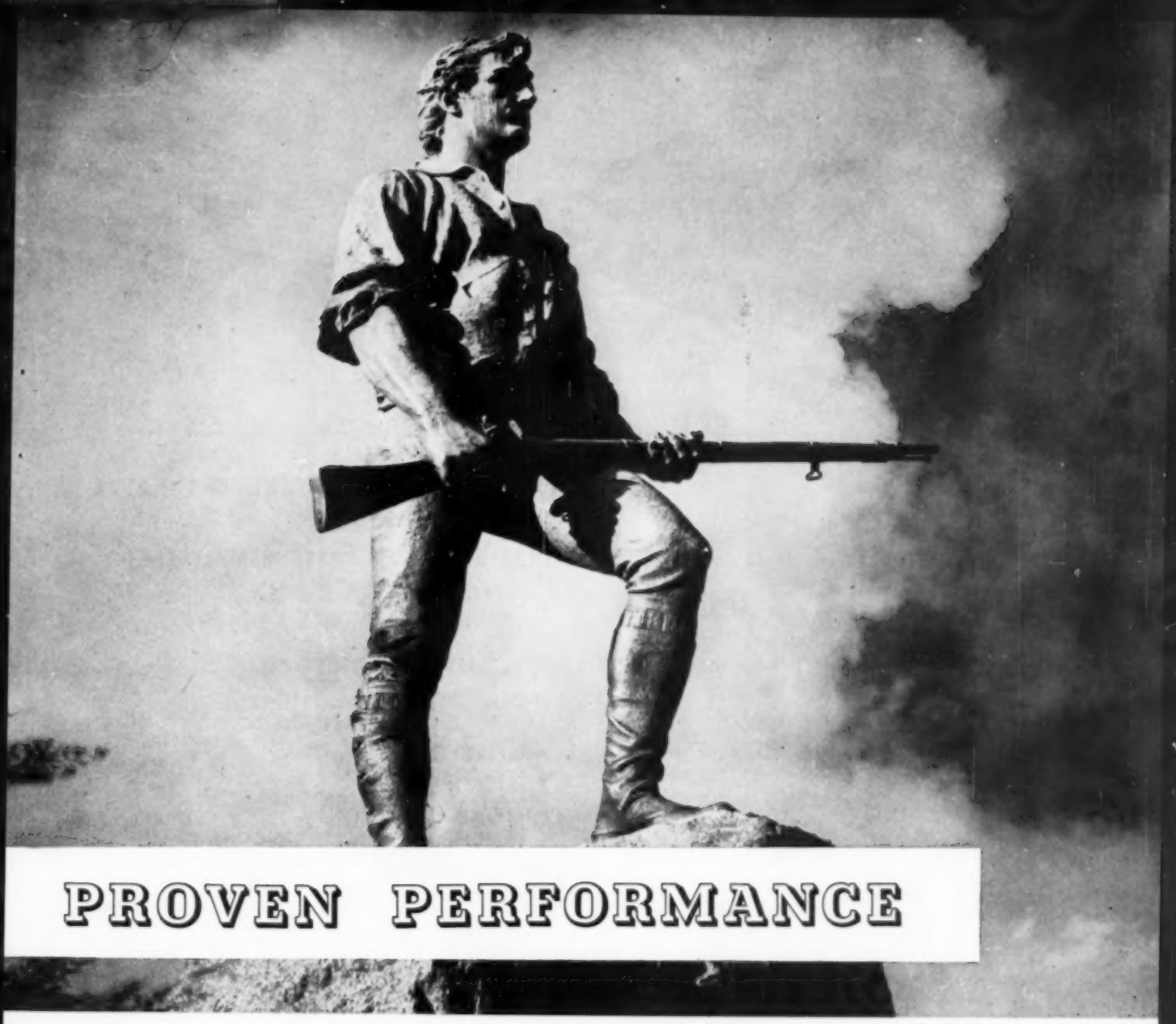
Chemical engineers have a great deal to contribute to this new field. We are taking a leading part in sponsoring meetings and in publishing information in the form of technical papers in the field. Last June we had a very successful International Congress on Nuclear Energy at Ann Arbor, which was attended by about 1,200 people. We have, as our first division of the Institute, a Nuclear Energy Division. Also at Ann Arbor we held the first Atomic Exposition. We are planning a second, and presumably a much larger one, and we believe it will be a much more successful one, in Cleveland in December. This will be in connection with a Congress on Nuclear Energy, being held under the auspices of the Engineers' Joint Council. We are planning to hold other expositions on this subject in connection with our Annual meetings.

We have taken, I think, the lead in this field, and we mean to keep it.

Another very interesting development is that of the possible new headquarters building for the five Engineering Societies. We have been asked to join with the four so-called Founder Societies (possibly others may be brought in later) in a common headquarters building. I think that this may be a very important step in promoting the solidarity of the engineering profession and in enhancing the prestige of the engineers before the public. We have, at this moment, offers from five cities—New York, Chicago, Pittsburgh, Philadelphia, and Washington—offers of a site and also of a certain amount of cash. There is a committee, composed of the five most recent presidents of these five societies, which is studying the problem and which has recently come up with a recommendation about one of these cities.

However, I would like to mention that the question of a site is not the only problem. There are some difficult questions to be resolved before the A. I. Ch.E. can join with these other societies. The others already have a building—they are in a Foundation, known as the

(*Continued on page* 84)



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Keeping it SIMPLE

HAMMEL-DAHL MAKES THE SAUNDERS VALVE
AUTOMATIC
—MAINTAINING ITS BASIC SIMPLICITY
and LOW COST

Superstructure

- H-D *ALLSTEEL*
  SECURELY FASTENED TO BODY
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- AIR-TO-OPEN
- PRELOAD (SPRINGLESS)
  THROTTLING CONTROL
- DUPLEX (SPRINGLESS)
  ON-OFF CONTROL

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CANADIAN MANUFACTURING AFFILIATE—GUELPH ENGINEERING CO., GUELPH, ONT.

for your information

This C.E.P. information service is a convenient way to get the chemical engineering information you need on the new equipment, on advertised products, on the newly announced developments reported on these pages. A one post card inquiry designed to bring data quickly and easily. Circle the items of interest, sign your name, position, address, etc., and drop in the mail.

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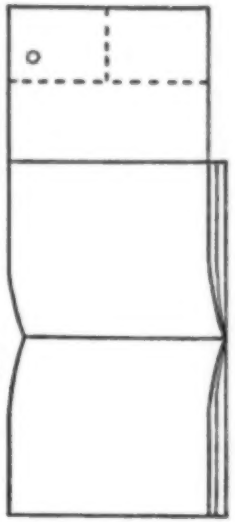

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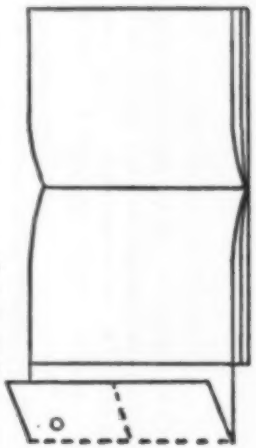

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CHEMICAL ENGINEERING PROGRESS
25 West 45th Street
New York 36,
New York

PRODUCTS

IFC **Bubble Caps & Trays.** Bubble caps designed for process needs, trays built for installations in shop or field. Special techniques employed. Vulcan Copper & Supply Co.

3R **Packers.** More material packed in a drum or barrel means use of smaller containers, cuts packing time, reduces labor. Several sizes of ViBrox packers available. B. F. Gump Co.

4A **Engineering & Construction Services.** Chemical plants designed, erected, & operated. Badger Mfg. Co.

5A **Valves.** Complete line of quality valves includes swing check, flush bottom, plug, & gate valves. Distributors will aid in solution of individual problems. Wm. Powell Co.

6A **Gas Separation.** Valuable products derived from waste gases & fluid flows by low-temperature liquefaction & separation. Air Products, Inc.

7A **Dowtherm.** This ideal transfer medium for high temperature, low pressure heat extends advantages of vapor-phase heating to higher temperatures than ever. Dow Chemical Co.

8L **Chemiseal Packing.** Teflon packing for all types of valves eliminates contamination, deterioration, & freezing shaft action. United States Gasket Co.

9A **Pulsafeeder.** For fluids difficult to pump—the Pulsafeeder. Unit is a highly specialized, custom-built machine for special applications. Lapp Insulator Co., Inc.

10A **Celite.** The diatomite structure of Celite steps up performance in paints, plastics, polishes, & other products. Johns-Manville.

11A **Durcopumps.** New series H pumps have only 3 bearing housings for complete range of sizes. Designed for heavy duty corrosion service. The Duriron Co., Inc.

12A **Transmitters.** Tough metering problems resolved by use of pneumatic transmitters. Unit measures flow, pressure, level or density. Republic Flow Meters Co.

13A **Crystallization.** A continuous crystallizer provides high purity crystals, uniform product, high output. Transfer coefficients of 300 B.t.u./hr./sq.ft./°F. Girdler Co.

14L **Panarez Resins.** This hydrocarbon resin used as a covering for wire improves product. Resins produce stocks which are economical, smooth, & glossy. Pan American Chemicals Div. Pan American Refining Corp.

15A **Valves.** A 6 in. valve which allows passage of 500 gal./min. cold water at constant drop of 1 lb. pressure. Provides largest flow coefficient available for size. Kieley & Mueller, Inc.

16A **Unibestos.** Amosite a South African asbestos adds greater strength & superior insulating ability to pipe insulation. Material is easily removed & reapplied when necessary. Union Asbestos & Rubber Co.

17A **Chemical Process Plants.** Long, specialized experience in design & construction of plants producing heavy chemicals. Chemical Construction Corp.

18L **Centrifugal Pump.** New, simplified single stage centrifugal pump type SVS designed for the process industries. For use with mechanical shaft seal & conventional packing. Pacific Pumps Inc.

19-20A **Valves.** Periodic lubrication of these valves an investment. Eliminates wear by friction; provides renewed seat for sealing; allows plug to be hydraulically jacked. Rockwell Mfg. Co.

21A **Graphite Process Equipment.** Equipment built from Karbate impervious graphite meet severe corrosion resistance needs. National Carbon Co., Div. Union Carbide and Carbon Corp.

22A **Microvac Pumps.** Automatic lubrication, no stuffing boxes, grease-fittings, or packing. Capacities 15 to 500 cu.ft./min. F. J. Stokes Machine Co.

23A **Process Equipment.** Available in all metals & alloys are all types of process equipment for the chemical industry. L. O. Koven & Bro., Inc.

24L **Fluid Control.** Hoke needle, toggle, & metering valves fitted with Hycar O-rings are sealed leak-tight. Pass vacuum tests right off the production line. Hoke Inc.

25A **Construction Service.** Emphasis on safety has resulted in smooth, speedy, trouble-free completion of construction jobs designed & erected by Blaw-Knox Co.

26A **Valves.** Plug type disc brass valves have long-wearing, hard seating surfaces in rugged, well-designed bodies for use in steam or other severe services. Crane Co.

27A **Ammonia Synthesis.** The Casale process proved in forty synthesis plants to be economical & give maximum yields of pure, liquid anhydrous ammonia. Foster Wheeler Corp.

28A **Centrifugals.** Two types of centrifugals to handle almost all filterable slurries. Variety of capacities, all units low in power required. Baker Perkins Inc.

30A **Air Preheater.** Complete details available on how the Ljungstrom air preheater can benefit you by heat recovery. Increases heat transfer rates giving more throughput. Air Preheater Corp.

32A **Reactor Design.** Increased ammonia demands are easily satisfied by the proper reactors. Capacities in excess of 300 tons now available. M. W. Kellogg Co.

35A **Turbo-Mixers.** Step by step from beneficiation of rock to end product units provide controlled agitation & maximum efficiency. Turbo planning engineers available. General American Transportation Corp.

37A **Valves.** Non-ferrous working parts of this valve result in easy working & long life in chemical atmospheres. Solid porcelain body. Lapp Insulator Co., Inc.

39A **Instrumentation.** Packaged pH systems, flow electrode assemblies, electrode switches insure correct application. Beckman Instruments, Inc.

41A **Pressure Filter.** Specially designed for liquid-solids separation through a pressure-vacuum differential. Eimco Corp.

43A **Automatic Controls.** Optimum throughput without impairing overhead purity has been accomplished by using this pressure drop method of control. Foxboro Co.

44-45A **Flow Control.** Controlled volume pumps cut chemical costs, protect product quality, meter accurately. Typical applications illustrated. Data sheets available. Milton Roy Co.

46L **Automatic Distilling Head.** A magnetic head which provides a reproducible semi-automatic reflux ratio control. Flexopulse regulating cycle timer. Ace Glass Inc.

Chemical Engineering Progress

Numbers followed by letters indicate advertisements, the number corresponding to the page carrying the ad. This is for ease in making an inquiry as you read the advertisements. Letters indicate position—L, left; R, right; T, top; B, bottom; A indicates a full page; IFC, IBC, and OBC are cover advertisements.

Be sure to give name, address, position, etc.

Remember, the numbers on the upper portion of the card bring you data on only the bulletins, equipment, services, and chemicals reported in these information insert pages. The lower portion of the card is for the advertised products, and is keyed not only to advertising pages, but also to the memory-tickling list under the heading Products.

47A Synthesis Gas. Design & erection of synthesis gas plants with variable ratios of hydrogen to carbon monoxide to suit your needs. Girdler Co.

48L Turbine Pumps. Verti-Line turbine pumps designed & engineered with many features for long life under tough conditions. Layne & Bowler Pump Co.

49A GLC Anodes. Proven performance in production of chlorine & caustic soda has increased the acceptance of these units. Great Lakes Carbon Corp.

50A Saunders Valve. Bodies of wide variety of materials, sizes ½ to 10 in., screwed or flanged ends, all steel superstructure are featured. Hammel-Dahl Co.

55A Process Equipment. Filtering, evaporating or crystallizing problems easily solved by Conkey engineers whose assistance is available. Chicago Bridge & Iron Co.

57A Demineralization. Units available which reduce dissolved liquids from 165 to 3 p.p.m. & supply iron-free water of controlled alkalinity. Permutit Co.

59A Storage Tanks. Experience in working & welding many alloys & clad materials, plus carbon & stainless steels, assures satisfactory fabrication of process tanks. Downingtown Iron Works, Inc.

61A Construction Specialists. Chemical & petroleum plants designed, engineered, erected, & operated by specialists. The Lummus Co.

63A Dryers. A stainless steel plastics dryer 60 in. x 32 ft. with polished interior surfaces prevents spoilage & color contamination. Has many features & was fabricated by C. O. Bartlett-Snow Co.

(Continued on back of this insert)

Please do not use this card after July, 1955

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Advertisers' Products

IFC	3R	4A	5A	6A	7A	8L	9A	10A
11A	12A	13A	14L	15A	16A	17A	18L	19-20A
21A	22A	23A	24L	25A	26A	27A	28A	30A
32A	35A	37A	39A	41A	43A	44-45A	46L	47A
48L	49A	50A	55A	57A	59A	61A	63A	64L
65A	66L	67A	68L	69A	70L	71A	72TL	72BL
73A	74L	75A	76L	77A	78TL	78BL	78BR	79A
80L	80R	81R	82L	83R	84TL	84BL	85R	86L
87R	88L	89R	90TL	90BL	91R	92L	92R	93R
94TL	94BL	95L	95R	96L	96R	97TR	97BR	100L
101BR	156A	IBC	OBC					

Chemical Engineering Progress Data Service

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Advertisers' Products

IFC	3R	4A	5A	6A	7A	8L	9A	10A
11A	12A	13A	14L	15A	16A	17A	18L	19-20A
21A	22A	23A	24L	25A	26A	27A	28A	30A
32A	35A	37A	39A	41A	43A	44-45A	46L	47A
48L	49A	50A	55A	57A	59A	61A	63A	64L
65A	66L	67A	68L	69A	70L	71A	72TL	72BL
73A	74L	75A	76L	77A	78TL	78BL	78BR	79A
80L	80R	81R	82L	83R	84TL	84BL	85R	86L
87R	88L	89R	90TL	90BL	91R	92L	92R	93R
94TL	94BL	95L	95R	96L	96R	97TR	97BR	100L
101BR	156A	IBC	OBC					

Chemical Engineering Progress Data Service

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Position .....

Company .....

Address .....

City .....Zone.....State .....

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April, 1955

PRODUCTS (*Continued*)

64L **Process Plants.** Complete information available on the development of process plants for fats & oils, resins, esters, & many others. Industrial Process Engineers.

65A **Ammonia Condensers.** Standardized designs for water-ammonia & ammonia-ammonia services. Recommendations available whatever your heat exchanger problem. Whitlock Mfg. Co.

66L **Heat Exchanger.** Called Aero equipment cools liquids & gases by evaporative cooling with atmospheric air. Saves 95% of cooling water. Niagara Blower Co.

67A **Chempump.** Proven performance in handling problem fluids without failure or leakage of any kind. Sizes ⅛ to 7½ h.p. Capacities to 250 gal./min. Heads to 195 ft. Chempump Corp.

68L **Adsorbents, Desiccants, Diluents.** Products meet varying needs. If you have a special problem consult the Floridin catalog. Floridin Co.

69A **Filters.** Push button control, smooth power retraction of tank, many other features aid in speedy filtration of heavy oils, chemicals, other products with high bulk residue. Sparkler Mfg. Co.

70L **Heat Exchange.** Whether you heat or cool water for makeup, process, or other use, chlorination will be required to combat slime problems. Consult Wallace & Tiernan.

71A **Slurry Pumps.** Specially designed to pump highly abrasive slurry is the Aldrich Triplex. Features solid porcelain plungers, & oversized oil pump for slow operation. Aldrich Pump Co.

72TL **Bubble Caps.** Bulletin 21 on bubble caps said to be largest compilation of engineering data. Lists 200 styles without die cost. Pressed Steel Co.

72BL **Liquid Coolers.** Coolers designed & built for chemical process liquids using any common refrigerants or brines. Inquiries solicited on special requirements. Richard M. Armstrong Co.

73A **DeZurik Valves.** Easy operating, non-lubricated plug valves fabricated of iron or steel, bronze, many other materials. Exclusive eccentric principle. DeZurik Shower Co.

74L **Heat Exchangers.** Impervious graphite heat exchangers resist spalling, give uniform heat transfer & have good corrosion resistance. Falls Industries, Inc.

75A **Heat Transfer Systems.** Beth-Tec molten salt heat transfer sysems for applications in your pilot plant, also your plant installations. Bethlehem Foundry & Machine Co.

76L **Electronic Flow Meters.** Element with turbine-type floating rotor generates current whose frequency is directly proportional to flow rate. Potter Aeronautical Co.

77A **Evaporators.** No matter what your needs are in the field of food product concentration these single-effect, high vacuum, low temperature downflow evaporators will supply them. Buflovak Equipment Div., Blaw-Knox Co.

78TL **Process Equipment.** Regardless of type of installation or process there is an Alsop unit to fit your needs. Variety of sizes & capacities. Alsop Engineering Corp.

78BL **Process Equipment.** For 25 years business has been fabrication of stainless steel, Monel, Inconel, nickel & aluminum process equipment. Alloy Fabricators.

78BR **Arched Wafers.** New process & new service announced. Arched wafers of your product have advantages over flakes & other shapes. Ask Flakice Corp.

79A **Rubber & Plastic Products.** Corrosion resistant equipment & parts for the chemical industry fabricated from plastics include pipe, valves, pumps, other units. American Hard Rubber Co.

80L **Fume Washers.** Units eliminate corrosive fumes. For scrubbing such gases as HCl, sulphur dioxide, chlorine, & others. Individually engineered. Maurice A. Knight.

80R **Sizing Machinery.** Several types of equipment available for producing granular materials uniform in length, width, or thickness. Literature available. Hart-Carter Co.

81R **Wire Cloth.** Made of all malleable metals such as aluminum, brass, bronze, also noble metals such as gold, silver, platinum, wire cloth to meet specific conditions. Newark Wire Cloth Co.

82L **Dryers.** Improve your product by consultation with a manufacturer of drying equipment who also has the knowhow to aid you in materials handling problems. Proctor & Schwartz, Inc.

83R **Process Equipment.** All types of kettles, reboilers, reactors or other equipment tailor-made to fit your process needs. Manning & Lewis Engineering Co.

84TL **Aerating Units & Level Indicators.** Aerating unit provides steady flow of dry, finely ground material which tend to bridge in storage. Level indicator for use on bulk materials. Signals level change. Bin-Dicator Co.

84BL **Automatic Liquid Handling.** Xacto meters for every plant are easily adapted. Choice of dials & controls for change in requirements. Bowser, Inc.

85R **Pump Packings.** Lattice braid asbestos packing with Teflon for use against caustics & other severe applications as well as the usual ones. Two types, sizes 5/16 to 1½ in. Garlock Packing Co.

86L **X-B Pump.** An external bearing pump without stuffing box, gaskets or valves. Unique design, selection of body block & liner materials. Vanton Pump & Equipment Corp.

87R **Heat Exchangers.** All types of equipment for power, refining, chemical & marine industries built upon long experience. Literally "engineer" out troubles. Condenser Service & Engineering Co., Inc.

88L **Demisters.** Use of this unit can increase feed capacity of process vessels 30 to 35%. Entrainment efficiencies above 99.9%. Otto H. York Co., Inc.

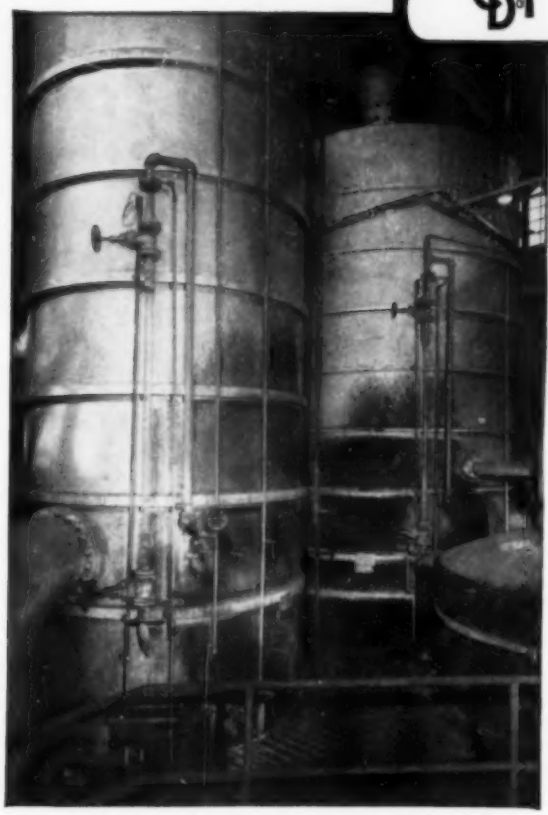
89R **Heat Exchangers.** Fabricated from stainless steel & designed to meet requirements of petroleum, chemical & petrochemical industries. Doyle & Roth Mfg. Co.

90TL **Wall Chart.** A four color wall chart of atomic nuclei. Includes all stable & radioactive nuclides. Long's College Book Co.

90BL **Laboratory Planning.** If you are building a new lab, catalog & planning guide available which includes 180 pages of ideas, layouts, specifications. Metalab Equipment Corp.

(Continued on page 56)

FORMULA
for Processing Problems:



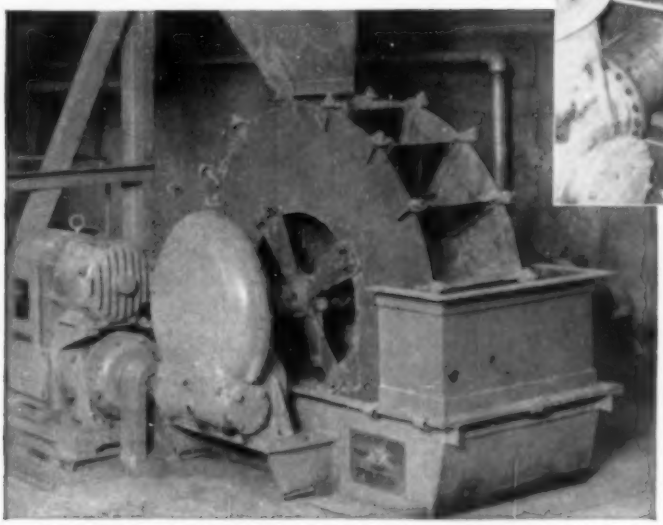
Conkey all nickel construction Triple Effect Evaporator producing 50 per cent caustic liquor.

Conkey Crystallizers, Evaporators and Filters

Here is your prescription to remedy crystallizing, evaporating and filtering problems . . . Conkey designed and engineered equipment, fabricated in Chicago Bridge & Iron Company's four strategically located shops, and erected by CB&I experienced crews.

If your plant has a filtering, evaporating or crystallizing problem, write our nearest office. A Conkey engineer will be happy to assist with information, estimates or quotations.

Conkey Triple Effect Vacuum Crystallizer producing ammonium sulphate.



Conkey Rotary Hopper Dewaterer in service dewatering abrasive grains.

CHICAGO BRIDGE & IRON COMPANY

Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PA.

CONKEY EQUIPMENT

Atlanta • Birmingham • Boston • Chicago • Cleveland • Detroit • Houston
Los Angeles • New York • Philadelphia • Pittsburgh • Salt Lake City
San Francisco • Seattle • Tulsa • Washington

PRODUCTS

(Continued from page 54)

91R **Stainless Steel Fittings.** Screwed, flanged, other types of stainless steel fittings of high quality, easily available from Cooper Alloy Corp.

92L **Pelleter.** Machine cuts plastics extruded in rod form into evenly sized pellets. Two sizes 5¾ & 10 in. widths. Up to 30 fly knives. Produce up to 5,760,000 pellets/min. Taylor-Stiles Co.

92R **Filter Paper.** If you have a filtration problem send it in for a filtration analysis to learn if you are using the correct filter paper. Eaton-Dikeman Co.

93R **Heat Exchangers.** The new Aerofin type B smooth-fin heat exchangers provide additional surface per sq.ft. of face area with less friction. Aerofin Corp.

94TL **Catalyst Supports.** Spheroidal & cylindrical pellets of 17 compositions & 3 degrees of porosity. All highly refractory & inert to most acids. Carborundum Co.

94BL **Rotary Presses.** In addition to rotary presses with capacities 65 to over 5,000 tablets/min., mixers, granulators, & ovens also available from Arthur Colton Co.

95L **Jet Mixer.** Swift, complete dispersion obtained by use of this vortexless jet mixer. Breaks up agglomerates to particle size & efficiently disperses. Hermas Machine Co.

95R **Ion Exchanger.** Now you can have de-ionized water where & when you want it. Unit is self-contained & completely portable. Illinois Water Treatment Co.

96L **Blender.** A double-cone blender with many outstanding features including air-operated control valve & charging & unloading device. General Machine Co. of New Jersey.

96R **Control Manual.** Control of pH & chlorine in 34 basic industries is subject of free reference manual. Also illustrates line of comparators. W. A. Taylor and Co.

97TR **Compressors.** Quick & easy to service, class ATH compressors have unique sectionalized air-cylinders which maintain low operating temperatures. Pennsylvania Pump & Compressor Co.

97BR **Nozzles.** Full cone, hollow cone, flat spray nozzle as well as many others listed in catalog from Spray Engineering Co.

100L **Antifoam Emulsion.** Both Antifoam EF emulsion & Antifoam A compound are effective at low concentrations against variety of foamers. Dow Corning Corp.

100TR **Research.** Small organizations or individuals without proper facilities may find research solves problems. Inquire. Foster D. Snell, Inc.

101BR **Chill-Vactor.** Units flash cool water, aqueous solutions & certain other liquids to temperatures down to 32° F. by partial evaporation at high vacuum. Croll- Reynolds Co., Inc.

156A **Support Plate.** Performance of any dumped tower packing improves with use of weir-type support plate. Sizes 12 to 60 in diameters. United States Stoneware Co.

IBC **Fintubes.** TF-18 tank heaters assure efficient, lower cost heating of stored products. Vertically mounted. Sediment cannot settle on heat transfer surfaces. Brown Fintube Co.

OBC **Fluid Mixing.** Equipped with rotary seals which eliminate stuffing box repacking & are easily replaced Lightnin mixers provide an entirely new concept in the field. Mixing Equipment Co.

CHEMICALS

1 **Sodium Nitrite.** Detailed information on use of sodium nirite as rust & corrosion inhibitor presented in "Sodium Nitrite for Rust and Corrosion Prevention," from Solvay Division of Allied Chemical & Dye Corp. Fully illustrated shows commercial applications other data.

2 **Acrylonitrile Derivatives.** Added to Monsanto Chemical Co. line of acrylonitrile derivatives is a group of nitrogen petrochemicals. Include beta, beta'-thiodipropionitrile. beta, beta'-oxydipropionitrile, beta-chloropropionitrile & beta-chloropropionic acid. All available in experimental quantities.

3 **Acetone.** A 12-page data folder on acetone includes data on physical & physiological properties, specifications, solvent properties, resin solubilities. Also information on performance in nitrocellulose lacquers. Carbide and Carbon Chemicals Co.

4 **Ion Exchange Resins.** From Dow Chemical Co. bulletin describing advantages & disadvantages in use of ion exchange resins as catalysts. Covers use of ion exchangers in industrial processes. New process described uses them.

5 **Tetrafluoroethylene Resin.** Manual available from E. I. duPont deNemours & Co. on Teflon tetrafluoroethylene resin. Covers properties, uses, processing techniques.

6 **Chloromethanes.** From Solvay Process Division, Allied Chemical & Dye Corp., a technical service report on chloromethanes — methyl chloride, methylene chloride, chloroform & carbon tetrachloride. Presentation of standard analysis methods.

7 **Glycol Carbonates.** Technical bulletin describing ethylene carbonate & propylene carbonate available from Carbide and Carbon Chemicals Co. Commercially available for use as solvents & plasticizers, as well as other purposes.

8 **Cyclohexanol.** Now available in tank car & carlot drum quantities cyclohexanol from Monsanto Chemical Co.

9 **Calcium Hydride.** Hydrimix a highly reactive powder form of calcium hydride soon to be produced by Metal Hydrides, Inc. in quantity. Said to be efficient drying agent for gases & liquids, also as condensing & reduction reagent.

BULLETINS

10 **Power Transmission & Conveying Equipment.** A 340-page guide from Link-Belt Co. covers complete line. Indexed, it contains selection information for the engineer or layout man. Sections on bearings, chain, clutches, gears, & couplings. Also on conveyors, elevators, etc. Capacity charts, & dimension tables included.

11 **Hydrogen Peroxide Vapor.** Possibilities for technological use of hydrogen peroxide vapor & means of vapor generation are subject of a bulletin from Becco Chemical Div., Food Machinery and Chemical Corp. Presents a summary of information on this material illustrated by tables & graphs. Also carries a bibliography.

12 **Amines.** A booklet describing the properties & characteristics of primary & secondary amines is offered by Armour and Co. Called "Armeens," the trade name for their amines, book is a revision of an earlier publication & is one of a number of such booklets on Armour's fatty acid & derivative products. Armeens are cationic surface active agents for use in the paint, oil, rubber, chemical, & textile fields.

This frothing unit pours liquid latex into molds.

Demineralized water helps GOODYEAR* maintain Airfoam* quality—and saves money, too!

The minerals dissolved in raw water carry electrolytic charges. If such water is used for latex dispersions, the rubber coagulates prematurely . . . causing excessive waste.

Goodyear tried distilled water . . . until increased production overtaxed the steam plant.

So Goodyear engineers looked into ion exchange. After evaluating various demineralizers, they selected Permutit resins and equipment.

Here's what they report after 4 years of continuous operation: "The Permutit units reduce dissolved solids from 165 to 3 ppm and supply iron-free water of controlled alkalinity. It has proved to be *higher in quality* than distilled water—at a considerable saving!"

Better water may solve your problem. Write to learn what Permutit can do to help you. The Permutit Company, Dept. CEP-4, 330 West 42nd St., New York 36, N. Y. or Permutit Company of Canada, Ltd., 6975 Jeanne Mance St., Montreal.

**T.M.'s The Goodyear Tire & Rubber Company*

ION EXCHANGE AND WATER CONDITIONING HEADQUARTERS

PERMUTIT®

BULLETINS

(Continued from page 56)

14 **Chemical Index.** A supplement from Fisher Scientific Co. "Bulk Chemicals," serves notice that the same high-purity lot-analyzed reagents known are now available to manufacturers & operators of pilot plants in 100 to 600 lb. drums. Covers over 100 reagent chemicals.

15 **Neoprene Notebook.** From E. I. duPont deNemours & Co., Inc. neoprene notebook No. 62 covering thermal properties & other phases of the use of neoprene.

16 **Polyvinyl Chloride Resin.** Designed to meet steadily increasing demands of plastic processors & fabricators for a resin which may be processed at temperatures from 315° F. to 330° F. a polyvinyl chloride resin announced by Diamond Alkali Co. Has a lower specific viscosity than earlier material, with lower molecular weight. Not intended to replace Diamond PVC-50 but to supplement it. Available in 50 lb. bags.

17 **Reference Manual.** A tabbed, easy to use 24-page reference manual from American Brass Co. contains the latest copper & copper-alloy specifications. This completely revised edition includes ASTM, ASME, AWS, many other specifications. Two sections—one of most generally used alloys manufactured; second lists specifications in numeric order with supplementary information.

18 **Horizontal Filters.** Horizontal rotary vacuum filters in sizes from 3 to 12 ft. in diameter described in bulletin from Filtration Engineers, Inc. Recommended for coarse crystalline materials, fibrous pulps & other free-settling or free-filtering applications. Filters are simply designed, have high capacity, fast dewatering & excellent cake washing.

19 **Water Sewage & Trade Waste Treatment.** New catalog from Hardinge Co., Inc. binder insert catalog treats with various clarifiers, backwash sand filters, flocculating units, & digesters. Illustrations, cutaway views, details on each unit, other data.

20 **Electraulic Weighing.** 1, 3 or 4 cell systems for eletraulic weighing from Automatic Temperature Control Co. are subject of folder which describes features, degree of accuracy, etc. Capacities to 100,000 lb. Cell of a particular size may be equipped with low capacity indicator. If requirements increase, higher capacity indicator can be added or substituted to operate original cell.

21 **Electronic Gauger System.** From Helipot Corp. a 4-page application data sheet which describes an electronic gauger system used in pipeline operations. Covers principles of operation, equipment, circuitry & use of Helipot precision potentiometers in this system.

22 **Thermocouple-Air Converter.** New bulletin on type T3C thermocouple-air converter. Unit permits users to retain pneumatic recording & controlling panel components & yet capitalize on Swartwout Co's. system of all-process control. Gives data on operation, mechanical & electronic specifications, ranges, dimensional diagram.

23 **Tanks & Process Vessels.** A 48-page catalog from Nooter Corp. covers in great detail their facilities & products, custom fabricated tanks & vessels for the process industries. Listed is corrosive action of 200 different chemicals in various concentration forms on 16 different metals. Data obtained from laboratories & large metal producers.

24 **Portable Demineralizer.** From Permutit Co. a compact, portable demineralizer unit for production of small quantities of pure water. Device contains a bed consisting of intimate mixture of Permutit Q, a cation exchanger & Permutit S, a highly-basic anion exchanger. Produces water with low total dissolved solids, CO_2, silica content & conductivity.

25 **Steam Condensers.** Condenser Service & Engineering Co., Inc. revised catalog illustrates many installations made by them. Sections on engineering, maintenance, installation, air removal equipment.

26 **Spectograph.** Bulletin from Jarrell-Ash Co. covers the JAco Ebert plane grating spectrograph with order sorter. Said to be first unit devoted to **all** spectra. Order sorter covers wide wave length coverage & good speed at high dispersion & resolution. Reproductions of several typical spectra.

27 **Flow Control Valves.** Service life of plug-type line valves said to be prolonged by reclaiming with spraywelded Colmonoy hard-facing alloy at Hamer Valves, Inc. Reduces warping, no rough machining required, steps for chrome plating avoided.

28 **Water Treatment.** In a new folder Hall Laboratories, Inc. outline the dangers of scale & corrosion in cooling systems & organic contamination of cooling system water. Determination of best treatment of water, said to require specialized knowledge, etc. Information given on solution of such problems.

29 **Graphite.** Illustrated brochure from Great Lakes Carbon Corp. on the growing significance of graphite in electrometallurgy & electrochemistry. Covers reasons, products, much pertinent information.

30 **Expansion Joints.** From Bellows Div., Solar Aircraft Co., illustrated catalog of expansion joints in their line. Tables on expansion & pressure.

31 **Voltmeter.** Automatic measurement plus digital display using Non-Linear Systems Inc. digital voltmeter. Instrument operates as self-balancing, digital potentiometer. Illustrated leaflet lists features, other data.

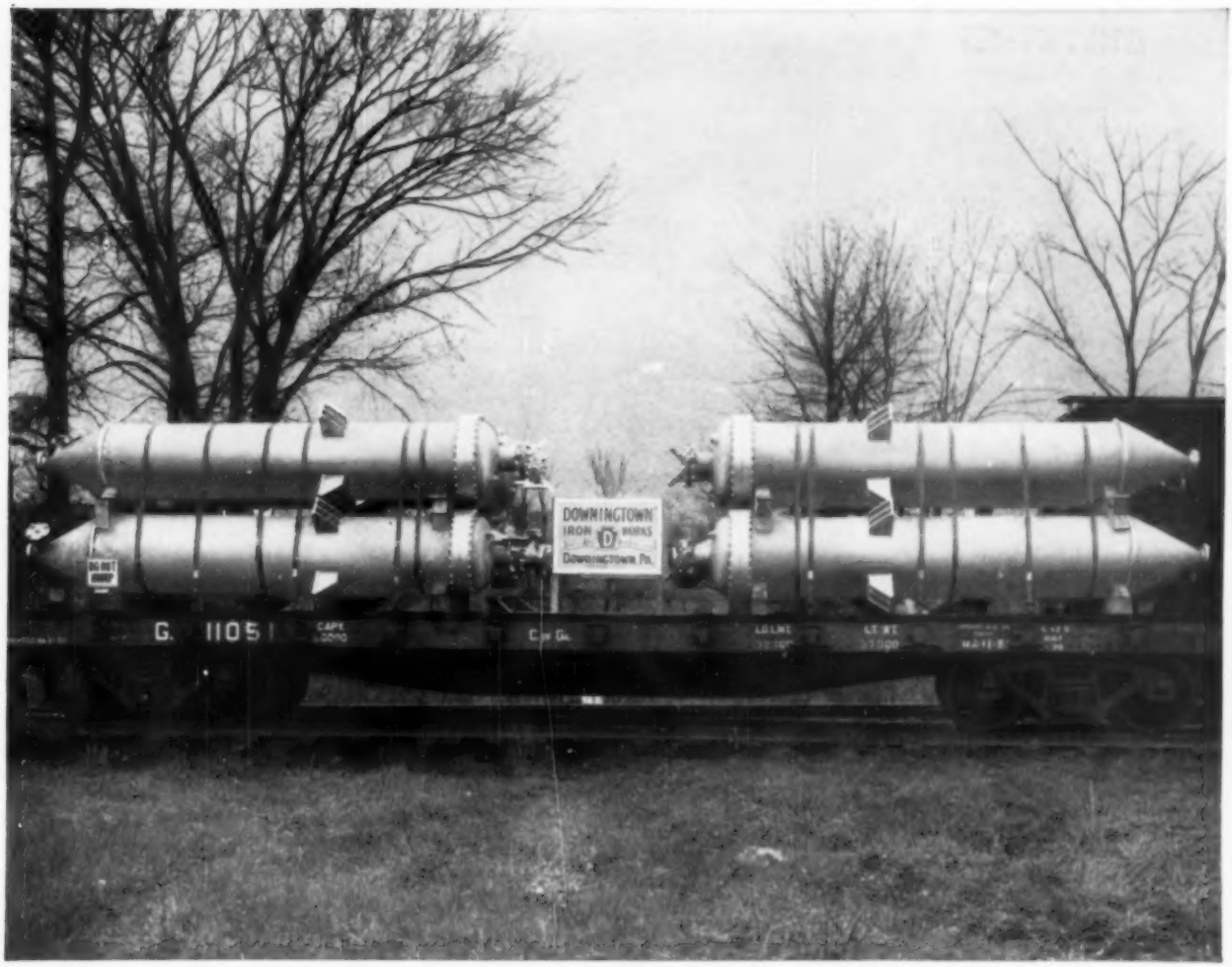
32 **Stainless Steels.** From Carpenter Steel Co. bulletin on stainless No. 20 & 20-cb. Covers analysis, annealing, recommended uses, yield strength, heat treatment, much additional information.

33 **Engineering Reference Tables.** A binder insert bulletin covering engineering data reference tables. Includes formulas for valve sizing; properties of saturated steam; steam flow in pipes, conversion & selection data, etc. Leslie Co.

34 **Petroleum Processing.** Bulletin from Kaiser Engineers illustrated with installations engineered & built. Equipped to handle planning, design & construction of petroleum & petrochemical processing plants.

35 **Research.** Vitro Laboratories Div. Vitro Corp of America makes available folder describing availability of their research services. Specialists in construction of atomic energy installations.

36 **Spray Drying.** Industrial spray drying plants with capacities to 5,000 kilos of powder produced per hour by Nichols Engineering and Research Corp. Bulletin lists materials to which system has been applied, describes the major variables in spray drying, gives diagrammatic sketch of unit, other details.



Another carload shipment of 8 process tanks, each 32" O.D. by 13'0" long, fabricated at Downingtown of stainless steel, type 304.

REPEAT ORDERS PROVE

Downingtown Built means Quality Built

These eight stainless steel process tanks form just one of many carload shipments ordered by one customer during the past several years.

Complete satisfaction with workmanship, price and delivery—that's why so many leading chemical, refinery and other process plants turn to Downingtown again and again with repeat orders for their complex plate fabrication work.

They know they can call on our experienced staff of engineers to help work out complex design and construction details. They know they can rely on Downingtown skill and experience for quality workmanship. They know Downingtown is thoroughly experienced in working and welding many alloys and clad materials, as well as the carbon steels and stainless steels.

Put your plate fabrication problems into experienced hands—at Downingtown Iron Works. Code work a specialty, and authorized insurance company inspection regularly available.

For further information, send for bulletin PF.

Downingtown Iron Works, Inc.

106 Wallace Ave., Downingtown, Pennsylvania

New York Office: 52 Vanderbilt Avenue, New York 17, N. Y.

HEAT EXCHANGERS • TOWERS • PRESSURE VESSELS • STORAGE TANKS • STEEL AND ALLOY PLATE FABRICATION

DIVISION OF: Pressed Steel Tank Company

Manufacturer of Hackney Products • Milwaukee 14, Wisconsin

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

BULLETINS

(Continued from page 58)

37 **Conveyor End Assemblies.** A new bulletin issued by Sandvik Steel Co. covers packaged terminal end assemblies for steel belt conveyors. Discusses tension end & drive & component assemblies & how units are ready to operate when mounted on framework.

38 **Corrosion Control.** Stainless pipe & tubing from Alloy Tube Div. of Carpenter Steel Co. & its use in solution of every corrosion problem is subject of bulletin. Covers types of corrosion, resistance applications, tests, resistance table, special alloys for super control.

39 **Density Control.** For continuous measurement & control of liquid density, the Densitrol. Bulletin illustrates operation & principle, lists performance characteristics, shows various types. For use in recording & control of blending, mixing, separation, other operations. Precision Thermometer & Instrument Co.

EQUIPMENT

46 **Direct Flow Triplex Pump.** Said to promise marked advantages & economies in many industrial applications & developed by Aldrich Pump Co. is unit called Powr-Pac. Has 2½ in. stroke & is a 25 h.p. direct flow triplex pump. Sectionalized fluid-end design. Working barrel may be had in carbon steel, aluminum bronze, stainless steel or Hastelloy. Plungers & valve seats also available in variety of materials. Illustrated bulletin.

47 **Bin Level Control.** An improved type heavy duty Tellevel bin level control now marketed by Stephens-Adamson Mfg. Co. Changes involve redesigned switch housing & deflector mechanism to reduce possibility of sticky material building up on unit. Pendant steel cone deflector replaced by steel pyramid. Switch housing now a one piece unit of spun steel tapped at one end for electrical conduit, sealed at other end by molded rubber grommet. Bulletin 11-O illustrated, shows cutaway views plus more other pertinent data.

48 **Canned Rotor Pumps.** A new series designated model CHS of 5 & 7½ h.p. Chempumps offers users leakproof pumping at heads of 195 ft. & capacities to 300 gal./min. Pumped fluid enters enclosed rotor chamber providing automatic lubrication of bearings. Only moving part is integral unit composed of rotor & impeller. Available in cast iron, stainless steel, Monel or Carpenter-20 construction as standard. Chempump Corp.

49 **Porous Fluorocarbon Filter.** Properties of porous Kel-F plastic, design & performance data on complete filters equipped with this media, available from Porous Plastic Filter Co. Porous fluorocarbon plastics with controlled porosity are produced by an exclusive process & fabricated into filters with great chemical resistance. Brochure describes several basic types of these new filters, gives data on pore size, particle size removal, & flow capacity.

50 **Irradiated Polyethylene.** Called Agilene-Ht, developed by American Agile Corp. a material of ordinary polyethylene which has had certain properties altered by subjection to bombardment of sub-atomic particles of high energy. In its irradiated form it withstands temperatures to 350° F. without melting. Available in wide variety of finished products & fabrications it is especially important to the chemical & food processing industries.

51 **Temperature Regulator.** New angle type T temperature regulators developed by O. C. Keckley Co. May be mounted directly on heat exchangers, instant water heaters, etc., which have inlet connections on top. Renewable wearing parts of stainless steel or bronze. Has over-run feature for protection of thermal element if temperature at bulb exceeds range.

52 **Capacitive Level Control.** Sensing of capacitive level with electronic controls terminating in air-pressure variations suitable for operating a pneumatic-diaphragm control valve combined in Belmont model DP level control from Thermo Instruments Co. Applicable to most non-adhesive chemicals, milk, oils, refrigerants such as ammonia & the Freons, all condensed gases over temperature range from 500 to —425° F.

53 **Dust Collector.** A compact granular dust collector which operates well over widely-fluctuating air volume ranges avaliable from American Air Filter Co., Inc. Outside-in twist that reverses normal tangential flow of centrifugal dust collectors is credited with giving unit high efficiency over wide range. Illustrated folder gives details of reverse-tangent principle, other data.

54 **Silicone Rubber.** Announced by Connecticut Hard Rubber Co. commercial production of two new silicone rubber compounds with high tensile strength & high tear resistance. Known as Cohrlastic HT molding 400 & HT extrusion 600. Presently available mechanical properties compare favorably with those of synthetic rubbers. Tensile strengths 200 to 300 lb./in. Available in form of sheets, molded parts, fabricated articles. Bulletin available.

55 **Vibration-Free Pumps.** High vacuum pumps free of vibration added to line of Kinney Mfg. Div., New York Air Brake Co. Balancing of rotating element reduces cause of vibration. Improvement makes compound & duplex models suitable for use in portable installations. Compound models recommended for electronics & television industries.

56 **Duplex Compressor.** New duplex compressor designated class HAE is a two-stage, heavy-duty, water-cooled angle type machine, in range 797 & 974 cu.ft./min. piston displacement, 125 & 150 h.p. Bulletin provides cutaway views, complete operational details. Said to have flexibility of installation, is compact, portable, & streamlined. Pennsylvania Pump & Compressor Co.

57 **Switches.** Explosion proof pressure & vacuum switches said to unusually compact, are accurate, repeat within ±1% of setting. Approved for hazardous locations, listings are for atmospheres containing vapors of ethyl, ether, naphtha, also natural gas or grain dust. Range from 30 min. of mercury proof vacuum to 150 lb./sq.in. pressure. Sense increasing or decreasing vacuum or pressure. Barksdale Valves.

58 **Safety Regulators.** New, low cost temperature actuated safety regulators type STACON VS announced by Ferris Stacon Corp. Primary use is control of vapor line in degreasers by shut off of flows of steam & gas to heating coil when vapor exceeds given level. Sizes ½ to 1½ in. control temperatures between 25 & 325° F. with 50° range of adjustment.

59 **Teflon Packing.** Designed to function at higher peripheral speeds than usual is Teflon yarn packing from Crane Packing Co. Recommended for corrosive service on pump shafts & valve stems. Sizes ⅛ through ⅝ in., 1/16 in. gradations.

60 **Spray Dryer.** A new semi-works spray dryer for applications where small, compact dryer is desired. Working space 7 x 9 ft. Entirely of stainless steel except for external bracing. Furnished as complete operating unit, includes heater & spray nozzle, product collector &

LION OIL COMPANY

J. B. ROGERSON,
MANAGER OF MANUFACTURING

EL DORADO, ARKANSAS

MANUFACTURING DIVISION

October 29, 1954

LUMMUS
DATE REC'D: NOV. 1, 1954
ROUTE TO: C.A.B.
REMARKS:

Mr. C. A. Barrere
Vice President
The Lummus Company
2707 Weslayan
Houston 6, Texas

Dear Mr. Barrere:

The construction of our chemical plant in St. Charles Parish, Louisiana, to produce 300 tons per day of ammonia, 450 tons per day of nitric acid, and 550 tons per day of ammonium nitrate pellets was completed by your company June 1, 1954, and was well within labor cost and time allocated to this project.

Please extend our sincere compliments to all of the people in your organization who worked on this project for a job well done.

Yours very truly,

LION OIL COMPANY

J. B. Rogerson
Manager of Manufacturing

JBR:mpd

Illustrated: The Lion Oil Co. chemical plant constructed by Lummus in St. Charles Parish, Louisiana

Lummus has recently been awarded the contract to engineer and construct a 60 ton/day anhydrous ammonia plant for Wesbraco Chemical Division of Food Machinery and Chemical Corporation.

THE LUMMUS COMPANY, 385 MADISON AVENUE, NEW YORK 17, N. Y.
DESIGNING ENGINEERS AND CONSTRUCTORS FOR THE PETROLEUM AND CHEMICAL INDUSTRIES

EQUIPMENT

(Continued from page 60)

structural steel support. Prefabricated, unit is transportable through usual size factory openings. Dries air to any desired temperature between 200 and 750° F. Bowen Engineering, Inc.

61 **Filter.** ClaRite filter from Croll-Reynolds Engineering Co. described in brochure. Primary use is fine filtration or clarifying. Operates on three-step principle of precoating, filtering & backwash cleaning which eliminates manual cleaning & disassembly for parts replacement. Used in process industry for acids, alcohols, beverages, solvents & water.

62 **Synthetic Filter Cloth.** Laboratory tested & for use on all types of filters & dust collectors, are Feon synthetic filter fabrics. Said to outlast ordinary materials. Folder shows chemical resistance chart, lists principal considerations. Available in Feon Dynel, nylon, orlon, Saran, other materials. Filtration Engineers, Inc.

63 **Pyrometer.** A device which simplifies changing reference-junction compensators when going from one type of thermocouple to another, available on Bristol Co. electronic Dynamaster multiple-point pyrometers. Unit is a small, cylindrical aluminum piece with opening in one end into which compensating resistor can be inserted. All junctions located in cylinder wall. High accuracy ratings on low ranges.

64 **Recorder.** A receiver recorder for pneumatic & electric transmission systems explained in detail in bulletin from Bailey Meter Co. Diagrams, cutaway views, specifications, other details included.

65 **Laminated Pipe.** Announced by Resistoflex Corp. a companion line to their Fluoroflex-T laminated pipe. Made of laminated fluorocarbon resins & glass fabric; same construction for heavier duty pipe. Use limited to working pressures of 50 lb./sq.in. Handles corrosive liquids at temperatures to 500° F. Available in lengths to 12 ft. & diameters 1 to 2 in.

66 **Cyclones.** Four basic model cyclones are subject of catalog from Equipment Engineers, Inc. Describes new features of molded pure gum replaceable lining & integral two-stage cylindrical design. Includes data on role of cyclones in classification & gives details of specific uses of each model.

67 **Conversion Guide.** From Peter A. Frasse and Co., Inc. a chart fully describing the new Aluminum Designation System of the Aluminum Assoc. Includes both old & new designations for easy conversion. Detailed description of workings of new four digit index system.

68 **Siliceous Pigment.** Cab-o-sil, a new white & almost chemically pure siliceous pigment offered by Godfrey L. Cabot, Inc. Different from other silicas because made differently. Unique properties with high chemical purity. Has extreme fineness, large functional external surface area, & unusual optical properties.

69 **Rotary Pumps.** Line of rotary pumps combining basic self priming, no stuffing box, no shaft seal. Design protects bearings from fumes or chemical attack. Available in capacities from fractional to 5 gal./min. with 0 to 50 lb./sq.in. discharge. Vanton Pump & Equipment Corp.

70 **Valves.** Low-cost valves for use on tubing developed by Autoclave Engineers, Inc. Designated as TubeLine, it can be cut into lines faster & easier than conventional valves. Pipe-threading eliminated. Tube is cut to desired lengths & burrs filed off. Adapter nut & sleeve then slipped onto tubing are connected to valve. Union forms gas-tight seal. Sizes ⅛ through ½ in. O.D.

71 **Cooling Towers.** Complete new line of mechanical draft cooling towers introduced by J. F. Pritchard & Co. Named Lo-Line this induced draft tower solves problem of low overall height; answers demand of metropolitan buildings. Concealed internal supply piping available to enhance appearance. Binder insert leaflet shows typical cross section, gives other valuable data.

72 **PVC Valve & Fittings.** Designed & engineered by Lunkenheimer Co. & named Luncor, valve resists most chemicals. Said to be first completely molded PVC valve. Exclusive molding process gives material greater strength. Costs less than stainless steel & other alloy valves. Molded in rigid form, for use with pressures to 125 lb. & 150° temperature. Now in Y-type globe design.

73 **Laboratory Glassware.** Complete line of glassware for both micro & conventional research work from Ace Glass, Inc. Called Mini-Lab unit features one standard size joint for most assemblies with component parts interchangeable regardless of purchase date.

74 **Kel-F Elastomer.** Information on the properties, compounding, vulcanization & fabrication of Kel-F fluorocarbon elastomer revealed by M. W. Kellogg Co. Developed in cooperation with Office of Quartermaster General of the Army, material will be commercially available soon. Strong resistance to oxidation by mineral acids, peroxides, alkalies, etc. Withstands immersion in white fuming nitric acid for long period.

75 **Spray Nozzles.** Added to nozzles fabricated by Spraying Systems Co., is line of industrial nozzles. Identified as 15° injector type FullJet nozzles. Smallest size is under 1¾ in. long, capacity of 1.5 gal./min. at 10 lb./sq.in. Largest is 17 in. long with capacity of 1,108 gal./min. at 100 lb./sq.in.

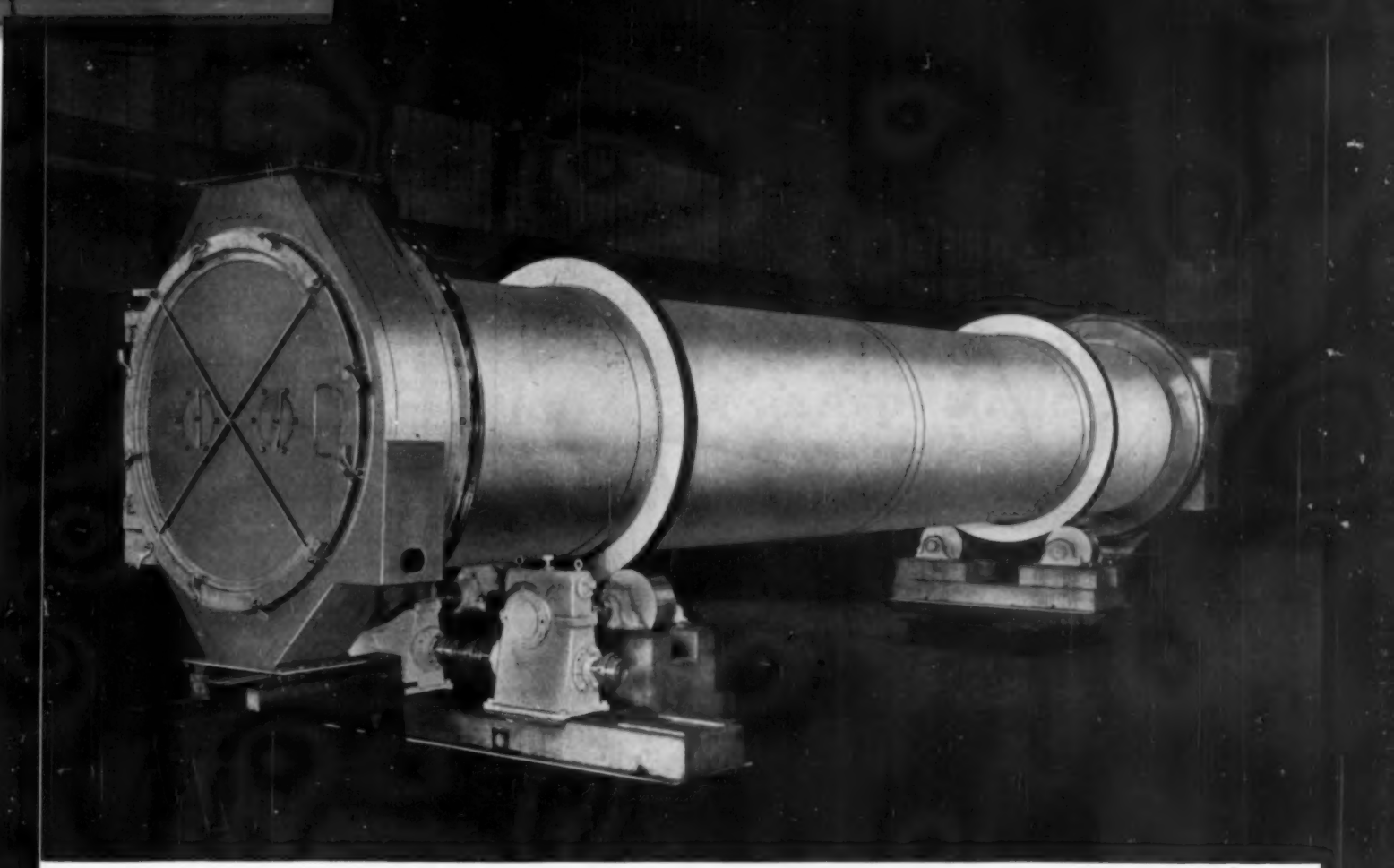
76 **Engineering Data Sheet.** From Milton Roy Co. data sheet which describes use of controlled volume pumps to proportion caustic soda to vegetable oil flow, assuring proper break. Second proportional feed system meters activated clay in bleach phase.

77 **Controller.** A low cost indicating controller for use on simple industrial processes introduced by Foxboro Co. Model 41A is pneumatic, provides sharp on-off or narrow band proportional control of temperature, pressure, liquid level, & humidity. When equipped for on-off action, controller snaps control valve from fully open to fully closed when measurement crosses control point. 5 in. measuring scale.

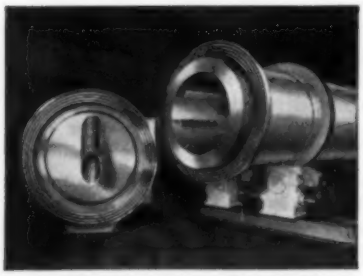
78 **Tank Heaters.** Thermo-Flo tank heaters manufactured by Brown Fintube Co. are covered in a binder insert folder. Said to be revolutionary in tank heating. Method agitates tank contents, performs heat transfer at lower temperature levels, leaves floor of tank free for easy cleaning. Oil cleaning unnecessary.

79 **Mechanical Scale.** Richardson Scale Co. has adapted its standard mechanically-operated bagging scale with a synchronized belt feeder & pneumatic inlet-gate assist. Now sacks 40% faster without loss of accuracy. Handles materials not formerly accommodated. Operates over greater weight range.

80 **Conductivity Cells.** Complete line of plastic-bodied conductivity cells announced by Industrial Instruments, Inc. Available in either dip or thread types. Choice of electrodes includes platinum, nickel, & carbon materials while cell constants range from 1/100 to 100. Ideal for use in strong alkali or acid solutions. Withstand temperatures to 100° C.



stainless steel *Plastics Dryer*



Labyrinth Seal on 60" x 32' 0" Stainless Steel Plastics Dryer showing the Mirror-like Finish on the Shell and Flights.

Special Steam Jacketed Batch Dryer showing Dustless Discharge to Screw Conveyor and Condenser where Fines are Reclaimed from Vapors.

60" x 32'0" stainless steel dryer with all interior surfaces polished to mirror finish prevents color contamination—and spoilage—between different batches of a well known plastic.

● This is probably one of the most costly direct heat rotary dryers ever built. Even the feed and discharge breechings and inspection doors are of stainless steel. Inlet air used for drying is filtered. Discharge air is passed through a stainless steel cyclone dust collector. Fabricated in our shops, this unit typifies Bartlett-Snow's ability to design and build equipment for even the most exacting operating and service requirements.

DESIGNERS
ENGINEERS

BARTLETT-SNOW
CLEVELAND 5, OHIO

FABRICATORS
ERECTORS

Dryers • Coolers • Calciners • Kilns

"Builders of Equipment for People You Know"

Process "Plants"
need to be developed with care too!

WRITE TO THE PROCESS PLANTS DIVISION FOR COMPLETE INFORMATION.

INDUSTRIAL PROCESS ENGINEERS

3 LISTER AVE., NEWARK 5, N. J.

I·P·E

ENGINEERS, DESIGNERS, FABRICATORS . . . PROCESS PLANTS AND EQUIPMENT

SPECIALIZING IN PLANTS FOR: Fats and Oils . . . Fatty Alcohols . . . Resins . . . Soaps and Detergents . . . Fermentation Products . . . Pharmaceuticals . . . Medium Organic Chemicals . . . Esters . . . and many others.

NUCLEAR ENGINEERING DIVISION

Detroit. The Detroit Joint Council on Nuclear Science has been formed, under the auspices of the Detroit Section of A.I.Ch.E. Following an exploratory meeting which took place December 1st when the Detroit Section invited representatives of 17 Detroit technical societies to its meeting on nuclear energy, a more recent (Feb. 25) organizing meeting has been held. The group elected a nine-man Steering Committee to organize the permanent Council and outline its functions and procedures.

D. W. Hartwell, head of Detroit Edison's atomic power development project, was named chairman of the Steering Committee. D. W. Anderson, secretary of the Detroit Section of A.I.Ch.E., and manager of Parke, Davis & Company's antibiotic department, was named secretary. Professor J. J. Martin of the University of Michigan, who is secretary of the Nuclear Engineering Division of A.I.Ch.E., was made a member of the Steering Committee.

D. W. Anderson

A preliminary report will be made April 1st, and a final report June 30th, on an engineering evaluation of a nuclear power plant system using liquid metal as fuel being made by a group of industrial and other specialists, under Babcock & Wilcox.

The liquid metal fuel system uses a liquid uranium-bismuth alloy in a reactor designed at Brookhaven, known as LMFR. Besides generating power, the reactor is intended to breed new fuel for itself, and deliver by-products to waste tanks. The liquid fuel stream would be interconnected to continuous processes—presumably fuel purification.

In December, 1954 the A.E.C. announced that reactor fuel would be made available to industry in the form of uranium enriched in various percentages of the fissionable isotope of U-235. A maximum enrichment of 20% U-235 by weight has been established by the Commission. Although the program still is in a formative stage it has been decided that, in general, the greater degree of enrichment desired, the smaller the amount of U-235 that can be obtained by a single applicant.

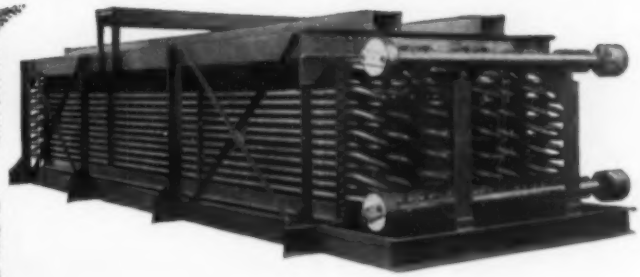
AMMONIA CONDENSERS...

STANDARDIZED IN DESIGN
PROVED IN PERFORMANCE

CASCADE TYPE

for water — ammonia service

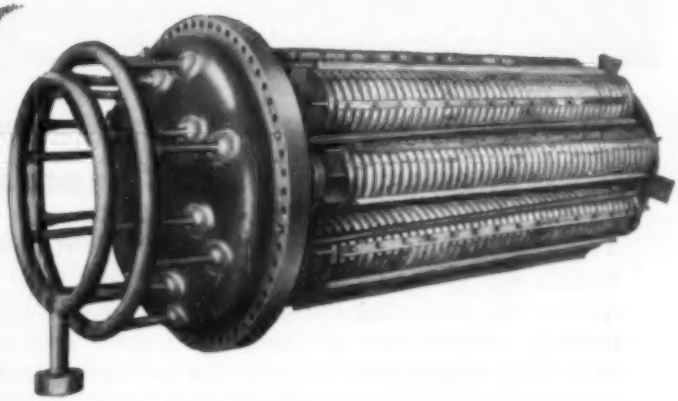
This cascade condenser, operating with water over the outside of the individual zig-zag coils, was designed for an ammonia pressure of 5,200 psig. The unit is furnished complete with frame work and catwalk as well as water distributing piping and necessary troughs. While the unit as shown is wholly constructed of steel, other designs with copper-clad steel or galvanized steel coils and headers are available when heavy corrosion on the water side is expected. This compact, standardized design is promptly available, efficient in use, and easy to maintain.



SHELL-and-COIL TYPE

for ammonia — ammonia service

The coils in this condenser are closely wound nested helicals with manifolds arranged as shown. The shell side design pressure is 165 psig and the coil side 5,200 psig. This unit has proved exceptionally economical to operate and maintain and its standardized construction, eliminating special engineering, assures lowest equipment cost.

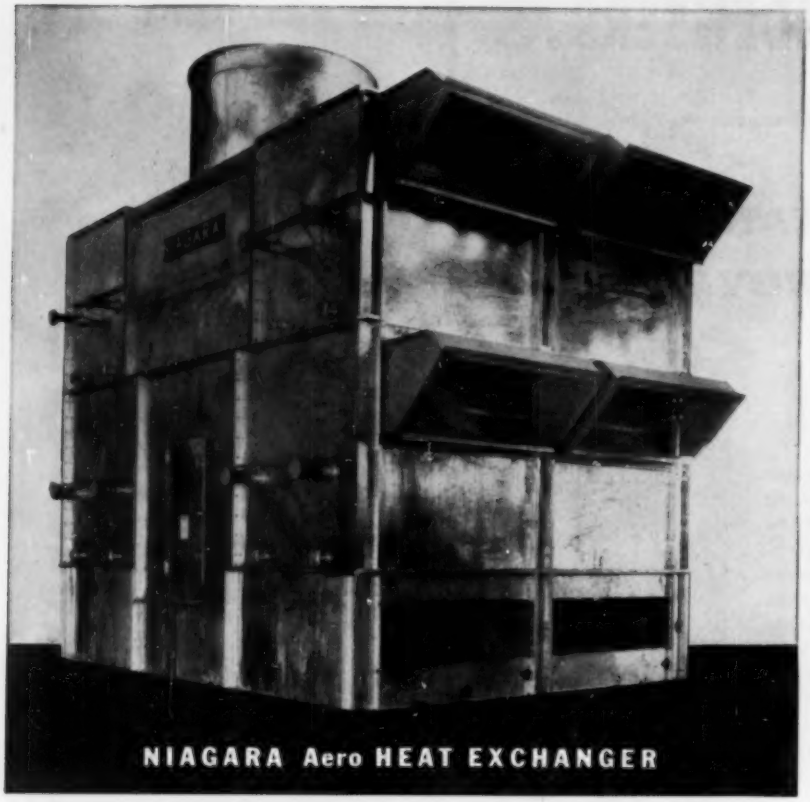


Whatever your heat exchanger problem, ask us for recommendations. Our long experience is at your service. The Whitlock Manufacturing Company, 97 South Street, West Hartford 10, Conn. In Canada: Darling Bros., Limited, Montreal.

Whitlock

Designers and builders of bends, coils, condensers, coolers, heat exchangers, heaters, piping, pressure vessels, receivers, reboilers.

Thirty Million B. T. U. CAPACITY



NIAGARA Aero HEAT EXCHANGER

Cooling in Chemical Processes with Precise Control of Temperature

The NIAGARA Aero HEAT EXCHANGER cools liquids and gases by evaporative cooling with atmospheric air, removing the heat at the rate of input, controlling temperature precisely. You save 95% of cost of cooling water; you make great savings in pumping, piping, power; quickly recover your installation cost.

You can cool and hold accurately the temperature of all fluids, air and gases, water, oils, solutions, chemical intermediates, coolants for mechanical, electrical and thermal processes. You obtain closed system cooling free from dirt. You solve all the problems of water availability, quality or temperature.

In CHEMICAL PROCESSES this is successfully used in cooling liquids and gases, chemical reactions, condensing distillations and reflux cooling.

Write for complete information; ask for Bulletins 120 and 124. Address Dept. EP.

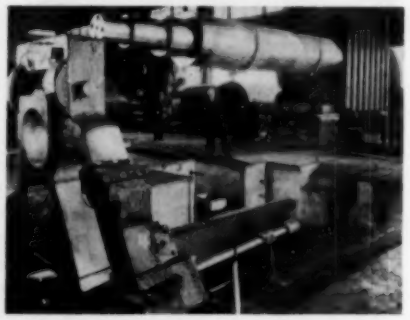
NIAGARA BLOWER COMPANY

405 Lexington Ave. New York 17, N. Y.

District Engineers in Principal Cities of United States and Canada

BUFLOVAK EXPANSION

Over an acre of floor space has been cleared at the Buffalo, N. Y., plant for the installation of machinery transferred from Pittsburgh, Pa., and the addition of new equipment, according to a recent anouncement. This has to do with the integration of Blaw-Knox Company's Process Equipment Department, formerly at Pittsburgh, into an enlarged and modernized Buflovak Equipment Division at Buffalo, N. Y. More than $1½ million will be spent.



A 100-ton pinch-type roll is one of the major items of equipment being added to the expanded Buflovak facilities. It will form 2½-in. thick plates up to 12-ft. wide at 60,000 lb. tensile.

Result of the consolidation will be extended product design, development and engineering facilities (already established). Manufacturing capacity will be enlarged, with accommodation of plates up to 4½ in. thick. Code welding, X-ray and cobalt gamma ray testing, heat treating, pressure testing, and modern development laboratory facilities will be available.

Equipment being added will include crane facilities, heavy forming rolls, a hydraulic press, and other forming machinery. Fabrication equipment will include heavy positioning rolls, turntables, and automatic welding machines.

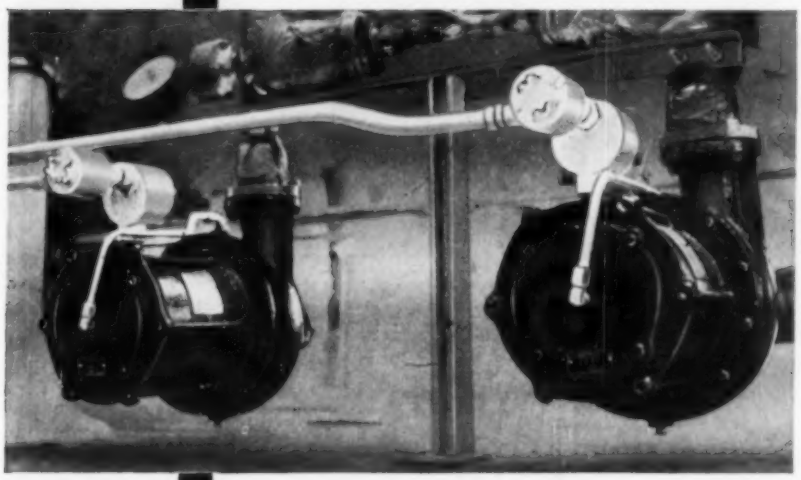
Shell Oil Company's refinery in Anacortes, Wash. will employ four Worthington turbines to drive centrifugal compressors for a fluid catalytic cracking plant. A 6,990 h.p. unit (condensing) and a 1,200 h.p. unit will drive air compressors. A 5,885 h.p. high speed condensing extraction unit will drive a gas compressor for a gas recovery plant, and a 1,500 h.p. unit will drive a reformer gas compressor. Each machine will have an automatic nozzle control and Taylor governor developed by Shell Development Company.

Reductions in prices of stock porous stainless steel filter units from 30 to 50% has been announced by Micro Metallic Corporation.

Chempump

handles problem fluids without failure or leakage of any kind...

at large midwestern chemical plant



Two 2-hp. *Chempumps* on 0°F service, handling liquid which tends to polymerize on contact with air . . . thereby forming hard crystals which could cause operational trouble with ordinary pumps.

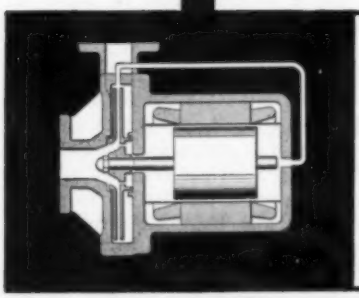
PROOF through *performance* is what sold this big chemical company on seal-less, leak-proof *Chempump.*

In one particular process, one man was kept busy just maintaining seals on small centrifugal pumps. When the *Chempump* was introduced, problem fluids were handled without failure or leakage of any kind. So far, maintenance has been no problem. The service these seal-less pumps have given is felt to more than justify the higher initial equipment outlay.

This is just another example of how *Chempump* has licked tough leakage problems! With this seal-less combined motor and pump unit, normally hard-to-handle fluids can't leak or become contaminated. Periodic inspection to indicate necessity of simple bearing change is the only maintenance required.

Your process can benefit through *Chempump*, too. For details, send for new 16-page Bulletin 1010. Chempump Corp., 1300 E. Mermaid Lane, Phila. 18, Pa.

Engineering representatives in over 30 principal cities in the United States and Canada.



Chempump combines pump and motor in a single hermetic unit. Pumped fluid enters rotor chamber; no shaft sealing device required.

Approved by Underwriters' Laboratories. Available in wide choice of materials . . . from ¼ to 7½ hp. Capacities to 250 gpm. Heads to 195 feet.

Chempump can't leak!

Chempump—
first in the field . . . process-proved

Please send me details on *Chempump* for:

_____
(application)

*Capacity*_____ *Total dynamic head*_____

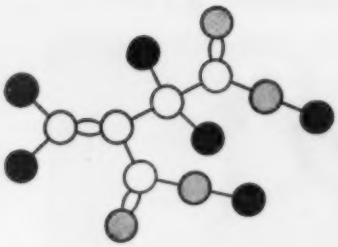
*Name*_____

*Title*_____

*Company*_____

*Address*_____

*City*_____ *Zone*_____ *State*_____



fermentation yields carload itaconic

Pfizer launches "first of a series we hope to announce over a period of months"—bulk organic chemical raw materials made by fermentation. . . . Question on the minds of several: Does this presage new era for fermentation—once thought obsolete?

Pfizer's recently announced itaconic acid —a highly reactive organic "building block" material—would be routine were it not for the emphasis placed on fermentation as its method of manufacture. With similar emphasis on the fermentation basis of two more new products, odor-free Citroflex * A-4 and Citroflex A-8, both commercially available, the trend points to a resurgence of fermentation and a new policy at Pfizer.

Not a new compound, itaconic acid has been studied as to applicability for many years. Since 1940, some 60 use patents have been issued—primarily in polymers, plastics and resins.

"Previously," stated Pfizer's president John E. McKeen, "the production of itaconic acid by fermentation processes required the use of relatively high-cost carbohydrates. Pfizer has now succeeded in developing a process for its production from a low-cost carbohydrate source." [Sugar, from cane or beets.]

Pfizer, long-time leader in fermentation processes, has entered into the tonnage manufacture-by-fermentation of such chemical products as itaconic for reasons of diversification. The pharmaceutical field, where Pfizer has concentrated in recent years, is, it seems, one which experiences quicker obsolescence than the average of the chemical industry as a whole. By turning partially to large volume, lower profit, chemical raw materials, it is expected that greater stability may be forthcoming. If demand warrants it, Pfizer can produce carload amounts of itaconic.

Itaconic acid's reactivity stems from its unhindered double bond. As an unsaturated dibasic acid it forms the usual carboxylic acid derivatives. The grade offered will have a specific gravity of 1.63 and a melting point of 165-6° C. Price will start at 59¢ in carload quantities, 60¢ in drums.

When asked to predict fields of major use, Greene indicated the following: 1-synthetic fibers, 2-insecticides, 3-automotive lubes (as pour-point depressants), 4-detergents, 5-surface coatings, 6-pharmaceuticals, and 7-plastics, for moisture-proof cellophane, plasticizers, or various resins. In the latter capacity, itaconic's ability to increase the surface hardness of methyl methacrylate plastics by co-polymerization was demonstrated.

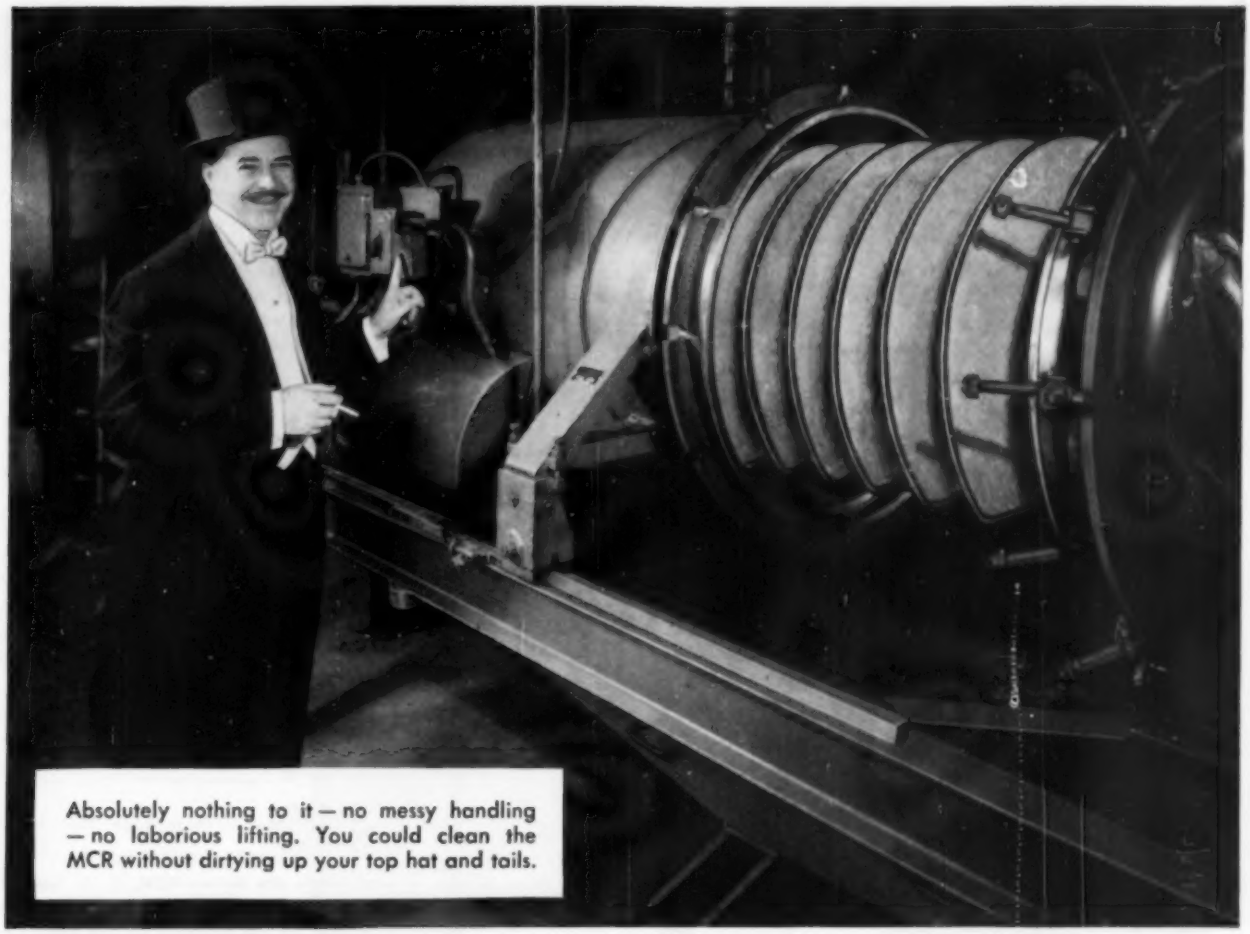
* Citroflex is Pfizer trade name for its citric acid ester plasticizers.

Meet
WIDELY VARYING NEEDS...

IN THE WHOLE SPHERE of adsorbents and desiccants there can be few uses to which Floridin products have not been successfully applied since 1910, when this company was established.

If you have a problem of selective adsorption—dehydration—decolorization—catalysis—in some one of the twenty specialized Floridin products—extruded Fullers Earth in various forms—activated Bauxite adapted to various processes—synthetic granular desiccants for precise laboratory requirements—in the Floridin catalog you will doubtless find an answer to your need. Your inquiry will be given careful, competent attention.

FLORIDIN COMPANY
ADSORBENTS DESICCANTS DILUENTS



Absolutely nothing to it — no messy handling — no laborious lifting. You could clean the MCR without dirtying up your top hat and tails.

The Aristocrat of Filters

Push button control — Smooth power retraction of tank — No breaking of pipe connections — Self sealing cover gasket — Complete plate drainage — are a few of the superior features of the Sparkler Model MCR Filter. The top hat quality in heavy duty diatomite filters.

SPARKLER VERTICAL PLATE FILTERS
TOP HAT QUALITY

Heavy oils, primary filtration of beer, heavy chemicals, and other products with a high bulk residue, are easily and speedily filtered in the Model MCR filter with highly satisfactory results.

The advanced, ultra modern operating features of the MCR filter make it the aristocrat of heavy duty filters. Old conceptions of filtering high bulk products must be revised in the light of this new filter development. Everywhere the MCR filter has been installed filtering costs have dropped materially.

Retractable Tank Model MCR filter available in capacities from 100 sq. ft. to 2000 sq. ft. of filtering surface.

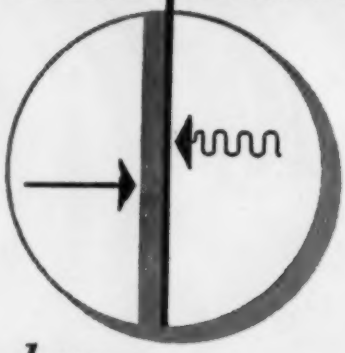
Write Mr. Eric Anderson for personal engineering service on your filteration problem

SPARKLER MANUFACTURING CO.

MUNDELEIN, ILL. • Sparkler International Ltd. • Plants at, Galt, Ontario, Canada; Amsterdam, Holland.

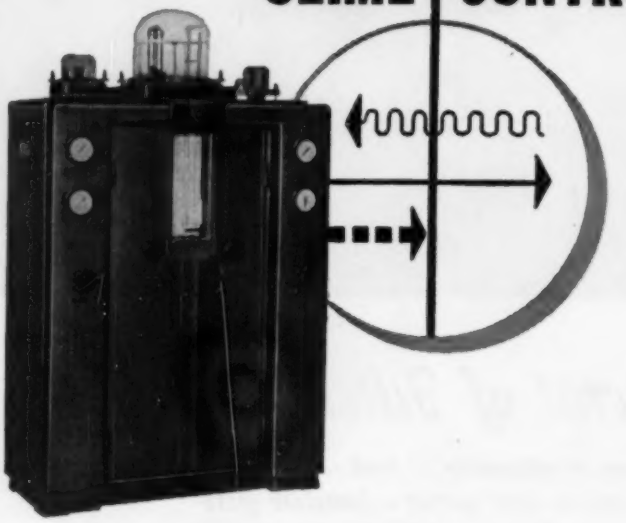
Where you need

HEAT | EXCHANGE



Be sure you have

SLIME | CONTROL



Whether you heat or cool water for make-up, process or any other use, you will need Wallace & Tiernan Chlorination to help combat slime problems introduced by water-borne bacteria or air-borne bacteria.

With slime control equipment designed for any need, built for lasting and dependable service, highly accurate and backed by over 40 years of successful application experience, Wallace & Tiernan Chlorination can help you increase the efficiency of your plant and cut operating costs. For further information write our Industrial Division.

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CD-39

STANDARDIZED PUMPS?

A move to bring about the development of dimensional and other standards for centrifugal pumps took place in New York on April 7th. Then the American Standards Association, acting on the proposal of the Chemical Industry Advisory Board, held an organizing meeting which was attended by representatives of more than 30 groups. As a result, it was decided that the Manufacturing Chemists Association and the Hydraulic Institute will co-sponsor a committee to study the subject. It was stipulated that ⅓ of this group be made up of pump manufacturers, ⅓ chemical plant operating firms, and ⅓ persons of general interest.

A Chemical Corps Statistical Symposium will be held at Army Chemical Center, Md. on April 28–29. Purpose is to bring together professional personnel from statistics and engineering for a closer working harmony and increase in efficiency. For further information contact Louis E. Garono, Chief Enginer, Chemical Corps Engineering Agency, Army Chemical Center, Md.

(*Continued from page 36*)

TECHNICAL SESSION NO. 8

SYMPOSIUM ON NUCLEATION, D. W. Oakley, Presiding.

A REVIEW OF THE THEORIES OF THE KINETICS OF NUCLEATION AND CRYSTAL GROWTH, C. R. Landgren, Bell Telephone Laboratories, Murray Hill, N. J.

ANALYSIS OF CRYSTAL SIZE DISTRIBUTION IN MIXED SUSPENSIONS, W. C. Saeman, Olin Mathieson, New Haven, Conn.

NUCLEATION AND GROWTH OF METAL PARTICLES AND CRYSTALS IN PHOTOSENSITIVE GLASSES, F. Schuler, Corning Glass Works, Corning, N. Y.

THE FORMATION OF CARBON BLACK FROM GASEOUS HYDROCARBON, C. W. Sweitzer and G. L. Heller, Columbian Carbon Co., N. Y.

TECHNICAL SESSION NO. 9

SYMPOSIUM ON NUCLEATION, D. W. Oakley, Presiding.

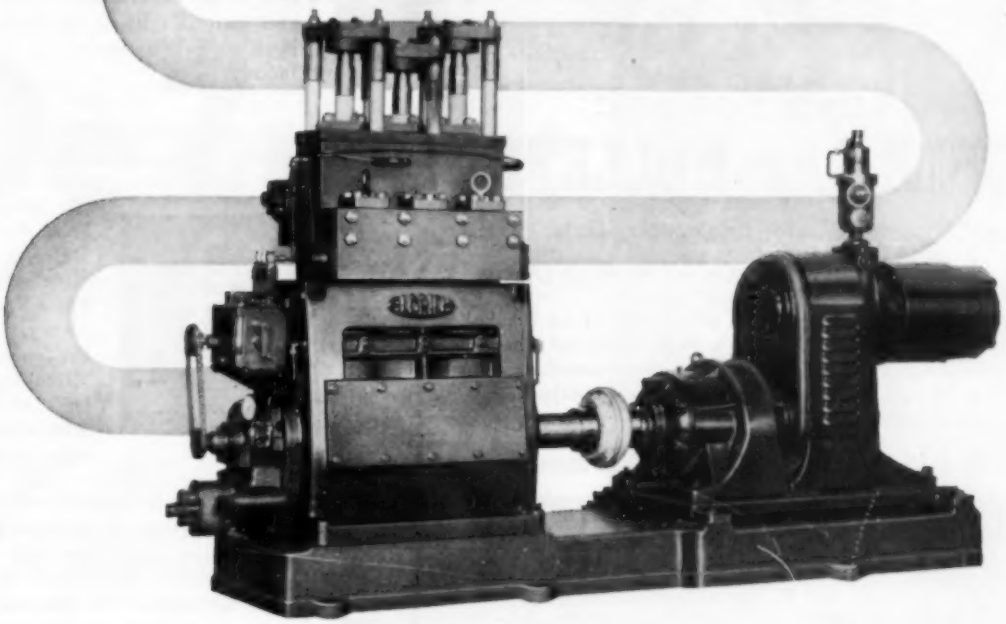
SIZE REDUCTION AND OTHER CHEMICAL ENGINEERING OPERATIONS CONSIDERED AS IRREVERSIBLE PROCESSES, W. H. C. Simmonds, Dominion Tar and Chemical Company, Montreal, Canada.

USE OF NUCLEATION TECHNIQUES IN THE TITANIUM PIGMENT INDUSTRY. A.–HYDROLYSIS OF TITANIUM SALT SOLUTION, J. O'Shaughnessy, National Lead, Sayreville, N. J. **B.–DEVELOPMENT OF PIGMENTARY TiO_2 FROM HYDROLYSATES,** G. Varnum, National Lead, Sayreville, N. J.

THE ROLE OF NUCLEATION IN OIL-SHALE RETORTING, M. W. Putman, U. S. Bureau of Mines, Rifle, Colo.

for your special pumping needs . . .

specify ALDRICH!



Here's an Aldrich Triplex specifically made to pump very highly abrasive slurry that would make short work of most pumps. A typical special Aldrich design, it features solid porcelain plungers—Kennametal ball valves and seats—an oversized oil pump for slow operation. Variable drive is provided by a U. S. Varidrive motor operated by Varitrol automatic control.

Aldrich Pumps are ideal for applications involving corrosion, high viscosity, high pressure, or abrasive materials . . . and the complete range of sizes insures a proper Aldrich pump for every need. Ask for recommendations to meet *your* chemical pumping needs.

the ALDRICH *pump company*

. . . Originators of the Direct Flow Pump

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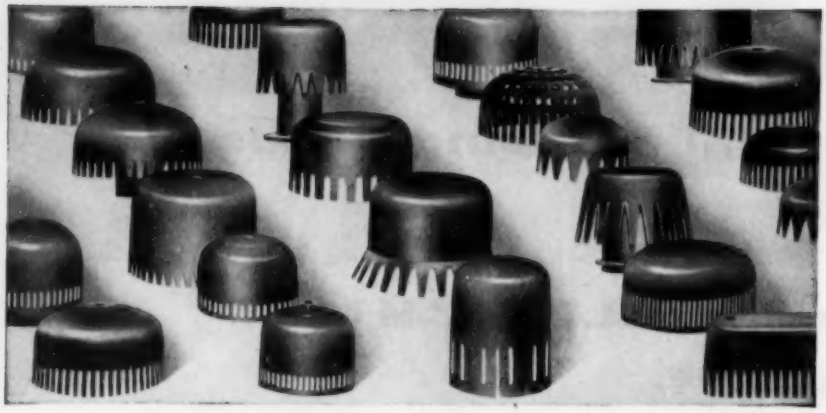

SEND FOR PSC

BUBBLE CAP BULLETIN 21

Largest Compilation of Engineering Data.

Lists 200 Styles Furnished Without Die Cost.

This standard reference contains complete specification information for over 200 standard styles of bubble caps and risers. Also drawings for use in determining methods of tray assembly. All styles listed in Bulletin 21 are furnished promptly, without die cost, and in any alloy to meet your coking or corrosion problems. Special caps gladly designed; write as to your needs.

THE PRESSED STEEL CO., 708 N. Penna. Ave., Wilkes-Barre, Pa.

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Custom Fabricators for the Process Industries Since 1928. Send Your Blue Prints

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LIQUID COOLERS

We design and build coolers for chemical process liquids, using any of the common refrigerants or brines.

Two 48" dia. x 20' tube length steel coolers for inorganic salt brine. Total of 10 tube passes, two shell passes. Total surface 7500 sq. ft.

We solicit your inquiry for coolers if they are:

1. **Comparatively large**
2. **Engineering is special or difficult**
3. **Metals require more than ordinary know-how**

RICHARD M. ARMSTRONG CO.
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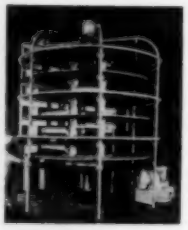
WEST CHESTER PENNA.

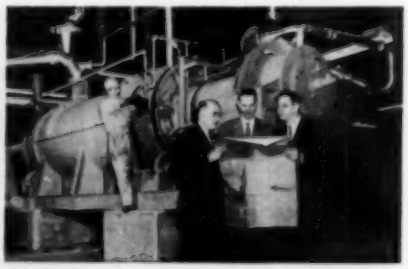
INDUSTRIAL NEWS

Sprout, Waldron & Company, Inc. of Muncy, Pa. has purchased the inventory, production machinery, designs and good will of Richmond Manufacturing Company, Lockport, N. Y. and is moving the facilities to Muncy. Richmond has been a manufacturer of sifters and other dry solids size-classification machinery. The addition of this equipment to the line of Sprout-Waldron size reduction and materials handling equipment will broaden S-W's services to the process industries.

A new rotary shelf cooler for continuously cooling and solidifying sulfur and materials with similar properties has been developed by Buflovak Equipment Division of Blaw-Knox Company, Pittsburgh, Pa. Called the "Roto-Shelf Cooler," the units consists of several circular trays mounted on a vertical drive shaft, each tray operating as a separate cooler. Molten liquid material is distributed on each shelf where it solidifies with the aid of cooling water distributed through the shelf by baffles. The layer of solidified material is lifted off the shelf by means of a stationary ramp. After being broken, the material is picked up by screw conveyors.



A new $1 million catalyst plant in Louisville, Ky., is being completed by the Girdler Company, of the same city. Operations performed in one section of the plant are dissolving, precipitating, coagulating, drying, and reducing. In another, calcining, drying, activating and reducing operations take place. Product catalysts are used for hydrocarbon reforming, CO conversion, hydrogenation, desulfurization and oxygen removal.

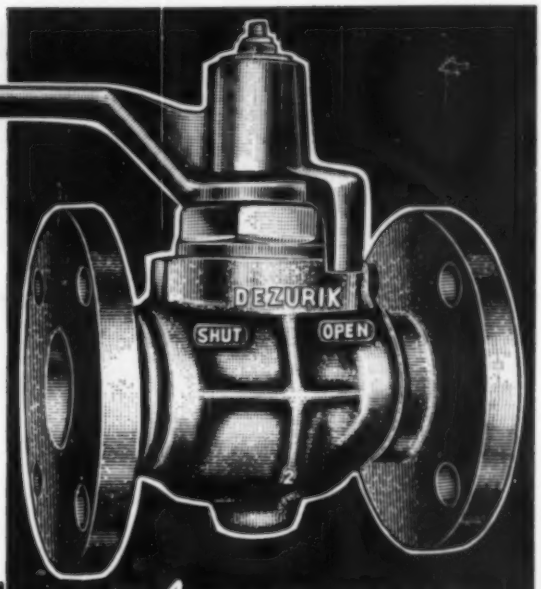


A Bartlett & Snow calciner is among the new Girdler facilities. Shown (l. to r.) are: J. E. Taylor, J. Cromeans, and R. E. Reitmeier.

the versatile valves in the chemical field...

DeZurik

Easy-Operating, Non-Lubricated PLUG VALVES



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STAINLESS STEEL

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ALUMINUM

and OTHER ALLOYS

On so many chemical lines . . . gas, liquid or dry solids . . . DeZurik Valves offer advantages found on no other valves. They're easier to operate—friction-free—only an e-a-s-y quarter-turn from wide-open to dead-shut. They're non-lubricated—no possibility of contaminating the flow—no "down time" for lube maintenance. They close tightly—without binding or sticking—without leaking! They are—without question—the versatile valves in the chemical field!

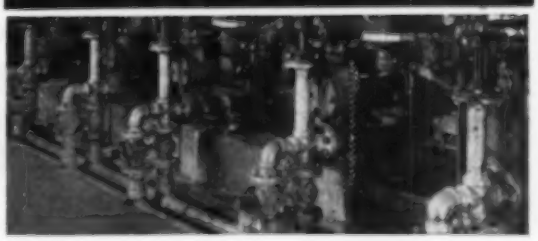
DeZURIK'S ***EXCLUSIVE ECCENTRIC PRINCIPLE***

OPEN FULL

DEAD SHUT

The rubber-faced plug in a DeZurik Valve is eccentric in cross-section, matching the eccentric-raised seat. When closing the valve, the plug turns freely until the face touches the seat. The wedging action seals dead-tight. In opening the valve, the first movement of the handle unseats the plug and it swings aside smoothly . . . quickly . . . easily!

DeZurik Valves are available with manual, remote or automatic operation; in sizes ½" thru 20". Write for service recommendations and details. Representatives in principal cities.



DeZURIK SHOWER COMPANY

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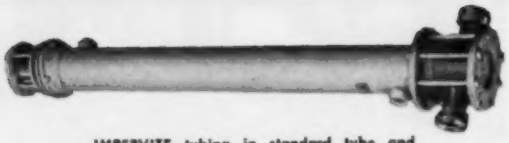
IMPROVED
Impervite
IMPERVIOUS GRAPHITE
HEAT EXCHANGERS
RESIST SPALLING • GIVE MORE UNIFORM HEAT TRANSFER
IMMUNE TO EFFECTS OF ALMOST ALL CORROSIVES



IMPERVITE tubing in standard tube and shell units resists spalling — gives more uniform heat transfer.

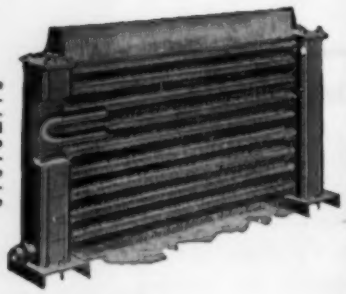
Exclusive CROSS-BORE exchanger design operates at pressures to 200 psi — resists physical shock — is easy to clean.

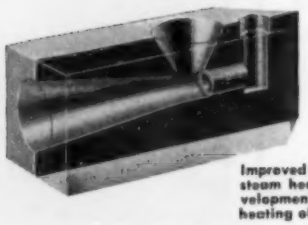
Four types of improved IMPERVITE immersion heaters are furnished as standard.

Experience, imagination and facilities make Falls the outstanding supplier of special, metal alloy exchangers for all purposes.

Custom designed 685-tube exchanger pictured indicates wide variety of IMPERVITE specials produced.

Improved tube extrusion and impregnation combined with special low-pressure-drop cells result in better performance records for IMPERVITE cascade coolers.





Improved IMPERVITE direct steam heater is a Falls development for economical heating of pickling solutions.

WRITE FOR CATALOG

Falls Industries Inc.

Cleveland's newest industrial suburb
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LOW PRESSURE POLYETHYLENE PROCESS

The long heralded low pressure (nearly atmospheric) process for making polyethylene resins is here—at least in pilot plant production—at Carbide and Carbon's South Charleston, W. Va. works. Softening points up to about 240° F. are indicated for the new type product—20 to 30 degrees higher than for conventional resins made by the high pressure process. Carbide currently has three plants in operation producing conventional types of polyethylene, at South Charleston, Texas City, Texas and Seadrift, Texas. These plants will continue making the conventional product. A fourth plant, at Torrance, Calif. will go into operation in about one year.

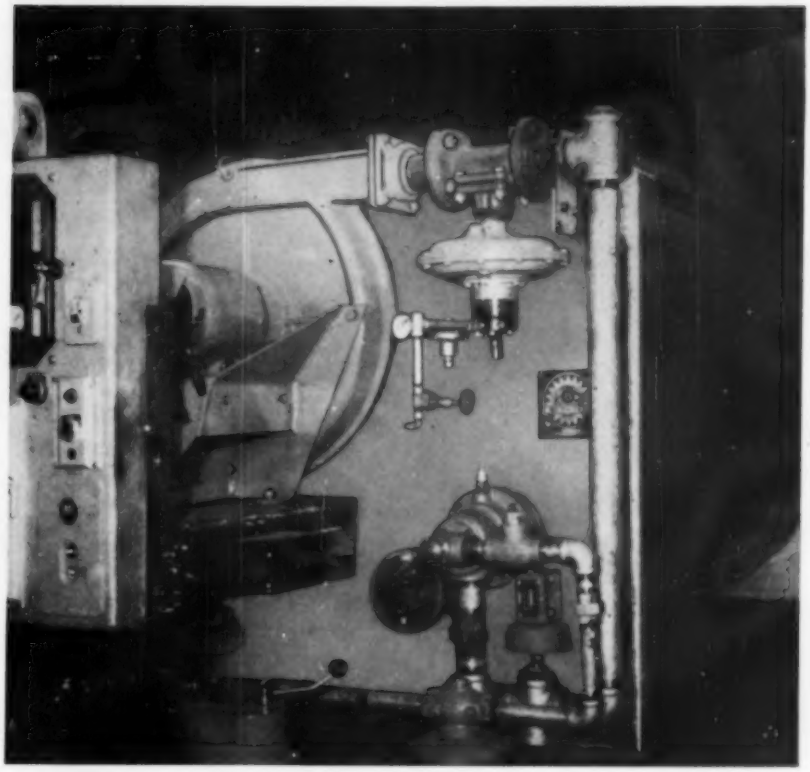
Both rigid and flexible foam polyurethane rubber materials will be produced in Wisconsin, according to an agreement between Mobay Chemical Company, licensor, and Albert Trostel & Sons Company, Inc. of Milwaukee. The latter firm is one of the world's largest tanners of side upper leathers. A subsidiary firm is engaged in industrial packings manufacture.

Polyurethanes, claimed to be the newest of synthetic polymers, are rubber-like materials made from isocyanates and polyesters. These basic ingredients will be manufactured by Mobay in a new plant now under construction at New Martinsville, W. Va. Mobay is jointly owned by Monsanto and Farbenfabriken Bayer, A.G., the latter of Leverkusen, Germany.

Nederlandsche Dow Maatschappij N. V. in Rotterdam, Netherlands will be the name of the new wholly-owned Dow subsidiary which will enable the parent firm to do business in The Netherlands. Dow plans to build a plant, tank storage, warehouse and dock facilities. The plant will process polystyrene plastic, magnesium alloys, glycols and other chemicals.

A new sulfur mine in the midst of a dense 100,000-acre cypress swamp, 50 miles west of New Orleans, is producing for Freeport Sulfur Company. This is a part of the firm's $25 million expansion program involving four new mines with a combined productive capacity of more than ¾ million long tons/yr.

The new mine, named Chacahoula, has facilities including a power plant to produce 3 million gallons of superheated water/day plus compressed air and electric power for the Frasch mining process, plus accessory facilities.



Pilot-size "Beth-Tec" direct-fired for salt bath temperature of 600°-700°F.

HIGH TEMPERATURE (650°-1000°F) REACTIONS CONTROLLED!

with "Beth-Tec" molten salt heat transfer systems

USE "Beth-Tec" in your pilot plant for control of high temperature reactions

- Heating and cooling exothermic reactions
- Ignition of catalysts

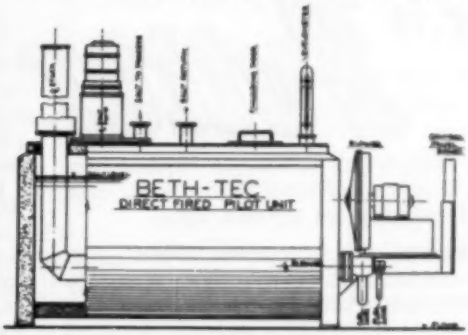
"Beth-Tec" is also effective for

- Heating metal-forming dies
- Cleaning of plastic mold parts

You will find "Beth-Tec" molten salt heat transfer system highly efficient for

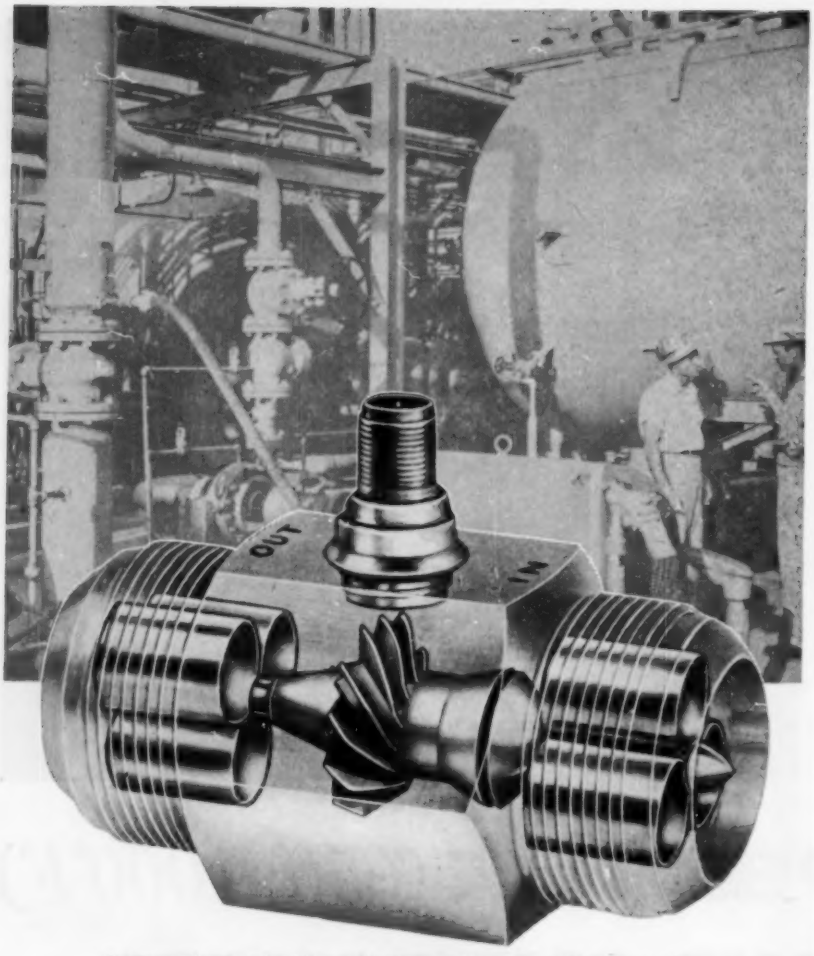
1. Close Control
2. Safe Operation
3. Good Heat Transfer
4. No Pressure Operation
5. Nontoxic Materials (DuPont Hi-Tec eutectic salt used)

Here is a standard model DF "Beth-Tec" for pilot operation.



- Note the compactly constructed, ready to run unit.
- Circulating systems (with pump) available, or heat transfer coil may be immersed in salt bath for constant temperature bath.
- Gas or oil fired systems available in capacities to 400,000 Btu/hr.

BETHLEHEM
Foundry & Machine Co.
Process Equipment Division
Bethlehem, Pennsylvania



Potter Electronic Flow Meters measure acids, caustics, suspensions at high or low temperatures and pressures with great accuracy!

if the question is flow the answer is Potter

● Potter Electronic Sensing Element with turbine-type "floating rotor" generates current whose frequency is directly proportional to flow rate. Inherently linear element has extremely wide rangeability, low pressure drop.

New Potter Electronic Flow Meters are used for accurate, foolproof, continuous measurement and control of hard-to-handle liquids with an accuracy of ± ½% of true flow over the recommended range. Supplying information in terms of weight or volume, they are efficient at temperatures from —450 to 1200°F and under pressures as great as 35,000 psi. Further advantages are swift, economical installation, low maintenance.

There are complete Potter Flow Meter Systems, including Recorders, Indicators and Digital Totalizers to meet your specific needs.

Write for Bulletin LS-1

Potter **POTTER AERONAUTICAL COMPANY**
Route 22 • Union, New Jersey • Phone Murdock 6-3010
makers of Potter engineered products

Organic isocyanates will be produced at a new $ multi-million National Aniline plant to be constructed on the Ohio River just south of Moundsville, West Virginia.

The plant will be a completely integrated organic isocyanates facility, with all chemical raw materials supplied from within the Allied Chemical & Dye organization. It will adjoin Solvay Process Division's new chlorine, caustic and chlorinated methanes plant, and National's recently completed maleic anhydride, fumaric acid, and catalytic aniline operations. Shipping facilities will include barge, railroad and truck. Design and construction will be under the supervision of F. J. Krueger, manager, National Aniline's Engineering Department.

The new facilities will establish National Aniline as a major producer of isocyanates for manufacture of polyurethane products.

The ammonia and nitrogen solutions plant to be built at Hammond, Indiana for Calumet Nitrogen Products Company will be designed, engineered and constructed by The Fluor Corporation, Ltd., Los Angeles.

Calumet is a subsidiary of Standard Oil Co. (Indiana) and Sinclair Oil Corp. and will manufacture ammonia for their marketing, from by-product hydrogen supplied by their nearby refineries.

Construction will begin this spring, with completion scheduled for 1956.

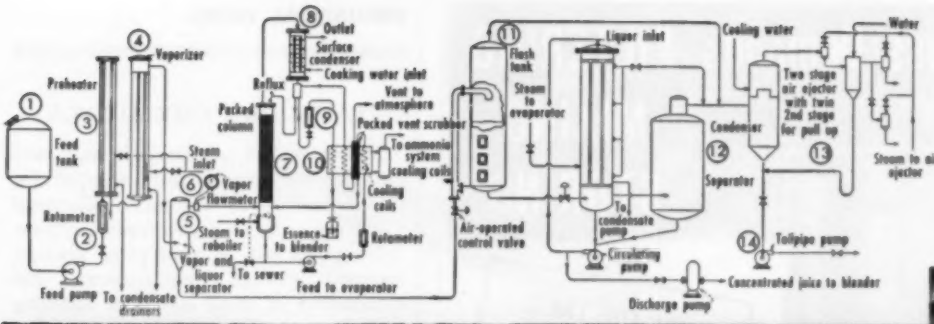
A joint venture by Freeport Sulphur Company and Pittsburgh Consolidation Coal Company will produce potash from a substantial deposit near Carlsbad, N.M. A new company, National Potash Company, has been formed for the undertaking.

$19 million will be spent on the mine, plant, and related facilities. Of this, $12.5 million will be borrowed from an insurance company. The operation will produce potash containing the equivalent of approximately ¼ million tons of potassium oxide per year.

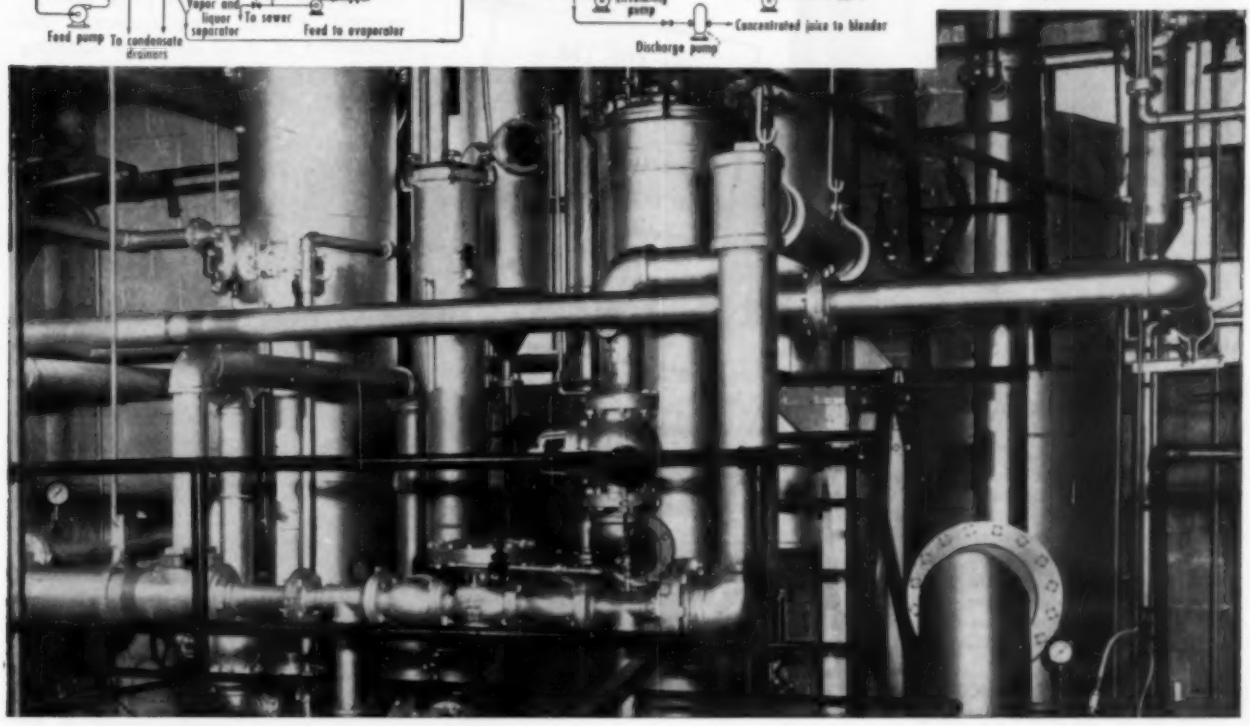
Freeport discovered the potash deposit in an area which produces about 90% of all U. S. production. Pittsburgh Consolidation will bring into the operation its broad experience in coal mining, in which the same machines and mining techique are employed as in the mining of potash.

Production is scheduled to begin in 1957. Principal use of potash is in fertilizers.

When Your Process Demands FILTERING



● A Buflovak De-Esterizer is used in combination with a Buflovak Low-Temperature Down-Flow Evaporator in the systems for producing Keystone concentrated grape juice.



To concentrate *heat-sensitive* grape juice without loss of flavor, Keystone selected

BUFLOVAK LOW-TEMPERATURE, DOWNFLOW EVAPORATORS

Tests proved that processing methods used for frozen orange juice concentrates could not be economically applied to concentrating grape juice without loss of flavor and aroma. The addition of raw juice "cut-back" to restore aroma and flavor proved to be unattractive economically.

Keystone Cooperative Grape Juice Association solved the problem with a Buflovak De-Esterizing System and a Buflovak Single-Effect, High Vacuum, Low Temperature Downflow Evaporator. Fragrant, volatile aromatics are first stripped from the raw juice and collected at a concentration of 100-150 fold. This essence is then returned to the finished juice after it is concentrated, giving it all its original fresh, full-bodied flavor.

No matter what the food product you make that needs concentration, Blaw-Knox Engineers can design and build Evaporators to fit the requirements for size of evaporator, temperature and pressure.

We invite you to bring your problem to us.

A Complete Process Equipment Service

Fruit Juice concentration is but one phase of Blaw-Knox Process Equipment design, engineering and fabrication service for the chemical, food, pharmaceutical, plastic and resin, petroleum, rubber and other industries:

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REACTION • VULCANIZING • CRYSTALLIZATION
SOLVENT RECOVERY • SOLVENT EXTRACTION
MIXING • POLYMERIZATION • GAS CLEANING
GAS ABSORPTION • VAPORIZATION • CONDENSATION
HEAT TRANSFER • STERILIZING • LOW and HIGH
PRESSURE PROCESSING • DISTILLATION

Everything in Process Equipment

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1567 Fillmore Avenue, Buffalo 11, N. Y.

Catalog 351 is available on request.

TOUGH ACE-ITE PLASTIC PIPE
General-purpose moderately priced rub-

When Your Process Demands FILTERING MIXING STORING

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EASY TO CLEAN
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LOW UPKEEP

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TANK CAR CHEMICALS

Molten maleic anhydride in bulk tank car has been successfully shipped for the first time by Monsanto Chemical Company's Organic Chemicals Division. Advantages will be unit price savings, lessened storage requirements, and elimination of small container handling and disposal. Rapid charging and lessened upheat time in reactors is also claimed, along with elimination of dust and fume problem. Cars will hold 8,000 or 10,000 gallons.

The first tank car of primary amyl alcohols left the Texas City, Texas plant of Carbide and Carbon Chemicals Company, on January 14th. In addition to this product, the processing unit produces primary decyl alcohols, and is designed to make a wide selection of other Oxo chemicals.

Isooctyl alcohol was recently shipped in tankcar quantity by Indoil Chemical Company from their recently completed oxo alcohol plant of Standard Oil Company (Indiana) at Wood River, Ill. The car went to Indoil's bulk storage facilities in an important consuming area to permit prompt tank truck deliveries to local customers. Isooctyl alcohol is primarily used in the manufacture of plasticizers for vinyl resins. Present plant capacity is 10 million pounds of the alcohol per year. Production of other high boiling alcohols having related uses is planned.

Carbide and Carbon Chemicals Company announces the first large scale commercial production of a group of reactive intermediates—acrolein dimer and its derivatives alpha-hydroxyadipaldehyde, hexanetriol-1,2,6, and tetrahydropyran-2-methanol.

Simpson Coal and Chemical Corporation, 120 Wall St., New York City, has announced intention to construct a 30,000 tons/yr. acetylene plant in Natchez, Miss. area, using natural gas as a raw material. The acetylene is to be used for an integrated vinyl chloride monomer and polymer installation, plus an ammonia plant of 60,000 tons/yr. capacity.

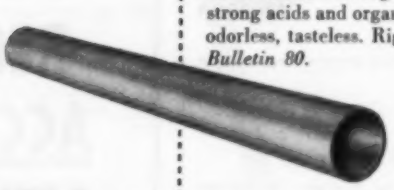
The addition of a special consulting service—to supplement Catalytic Construction Company's (Philadelphia) engineering and technical staffs in solving water problems arising in the design, engineering and construction of new plants—has been announced. This service will be rendered by the Sheppard T. Powell Organization of Baltimore, Md.

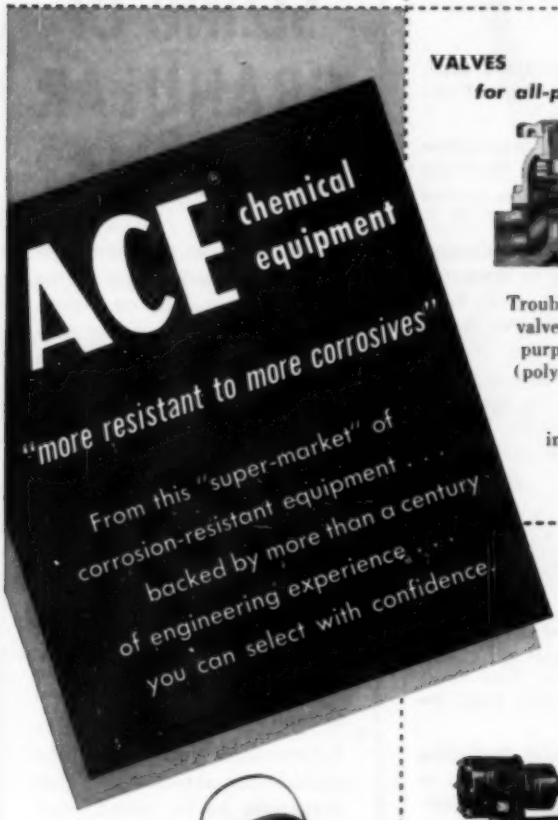
Chromate

FUTURE MEETINGS

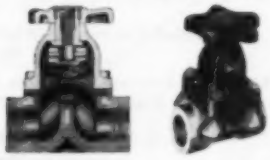
TOUGH ACE-ITE PLASTIC PIPE

General-purpose moderately priced rubber-plastic pipe handles most common chemicals to 170 deg. F. . . . except few strong acids and organic solvents. Tough, odorless, tasteless. Rigid pipe ½" to 6". *Bulletin 80.*




ACE chemical equipment
"more resistant to more corrosives"
From this "super-market" of corrosion-resistant equipment . . . backed by more than a century of engineering experience . . . you can select with confidence.

VALVES
for all-plastic piping systems



Trouble-free plastic diaphragm valves . . . choice of general-purpose ACE-ITE, ACE PARIAN (polyethylene) or ACE SARAN. Handles most corrosive chemicals and food ingredients. Sizes ½" to 2", 50 psi. at 77 deg. F. *Bulletins 80 and 351.*

NO SHAPE TOO SCREWY
for ACE Rubber Linings and Coverings

Most any size or shape of special processing equipment can be lined or covered with quality ACE hard or soft rubber . . . for meticulous protection against corrosion, to resist abrasive wear, or to provide electrical insulation. Ask for recommendations.

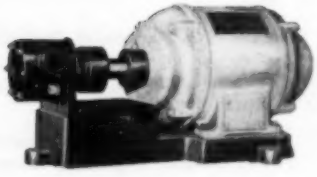
STAYS TOUGH AT SUB-ZERO TEMPERATURES

ACE PARIAN . . . odorless, tasteless, rigid polyethylene. Best chemical resistance of any plastic at room temp. except to acetic acid. Excellent impact strength at sub-zero temp. Rigid pipe ½" to 2". *Bul. 351.*

ACE-HIDE ACID PAIL

Practically indestructible

Its made of a new rubber-plastic material that's tough, resilient, suitable for handling most acids and alkalis. 3-gal. size. Easy-pour, drip-proof spout. Also 1-qt. and 2-qt. dippers, hard rubber bottles, etc. Write for name of nearest dealer.



MIGHTY MIDGET
for pumping acids

Jabsco neoprene-impeller pump made of ACE hard rubber out-lasts, out-pumps anything in its pressure, size and price class. Capacity from 15 gpm. at 22 ft. head to 5 gpm. at 72 ft. head. *Ask for free Bulletin 97.*

STOP VALVE CORROSION
at lower cost

There's an ACE hard rubber, rubber-lined, or plastic-lined gate valve for every corrosive application. Sizes from 2" to 24". Ace Standard or Darling types. Also diaphragm and check. Free *Bulletin CE-52* lists chemicals that can be handled.

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■ **LOS ANGELES, CALIF.**
Feb. 26-29, 1956. Statler Hotel.

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Chlorine
Benzol and HCl
Sulphuric Acid and Dust
Muriatic Acid and Chlorine

Every Pyroflex-constructed Fume Washer is individually engineered for maximum efficiency. In each case Knight engineers consider individual requirements, limitations, water consumption and fan power, as well as service conditions. The result is an engineered functional unit "tailored" to meet specific requirements. These units utilize Berl Saddles to insure peak performance.

Although individually engineered, Knight Fume Washers are relatively low in cost and economical in operation.

When writing for information, please include full details regarding service conditions.

Advantages

- **No moving parts.**
- **Low pressure drop, low power costs.**
- **Wide operating range.**
- **No temperature limitations.**
- **Simple to operate, low maintenance.**
- **Corrosion resistant throughout.**
- **Wide range of shapes and capacities.**
- **Small floor space, low head room.**

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Acid and Alkali-proof Chemical Equipment

FUTURE MEETINGS and Symposia of the Institute

MEETINGS **SYMPOSIA**

Detailed Houston meeting program appears on page 33.

■ **LAKE PLACID, N. Y.**

Sept. 25-28, 1955. Lake Placid Club.

A meeting devoted to the problems of interest to top management.

NOTE—No general papers

TECHNICAL PROGRAM CHAIRMAN: L. J. Coulthurst, Mgr. Proc. Engr., Foster Wheeler Corp., 165 Broadway, New York 6, N. Y.

Chemical Engineering Organizations of the Future

CHAIRMAN: J. F. Thornton, Pres., The Lummus Co., 385 Madison Ave., New York 17, N. Y.

Growth of the Oil & Chemical Industry by Integration

CHAIRMAN: F. M. Simpson, Vice-Pres., Petroleum Chemicals Inc., 54 Wall St., New York 5, New York

Packaged Power

CHAIRMAN: H. Arthur Martin, Exec. Vice-Pres., J. F. Pritchard Co., Kansas City, Mo.

Deadline—May 25, 1955

Atom Profits

CHAIRMAN: Dr. W. Kenneth Davis, Reactor Dev. Div., U. S. Atomic Energy Comm., 1901 Constitution Ave. N.W., Wash., D. C.

■ **ANNUAL—DETROIT, MICH.**

Nov. 27-30, 1955. Statler Hotel.

TECHNICAL PROGRAM CHAIRMAN: T. J. Carron, Supervisor, Chem. Eng. Section, Ethyl Corp., Res. Labs., 1600 West Eight Mile Road, Detroit 20, Mich.

Biochemical Engineering

CHAIRMAN: Dr. H. O. Halvorsen, Dept. of Bacteriology, Univ. of Illinois, 362 Noyes Lab of Chem., Urbana, Illinois.

Technical Societies Cooperation with Chemical Engineering Industries

CHAIRMAN: Prof. J. B. Phillips, Dept. Chem. Eng., Phys. Sciences Centre, McGill Univ., Montreal 2, Canada.

Mechanics of Bubbles and Drops

CHAIRMAN: Prof. R. C. Kintner, Dept. Chem. Eng., Ill. Inst. of Tech., 3300 Federal St., Chicago 16, Ill.

Standardization of Centrifugal Chemical Pumps

CHAIRMAN: C. J. B. Mitchell, Engineering Service Div., Engin. Dept., E. I. duPont deNemours Co., Inc., Wil., Del.

Evaporators

CHAIRMAN: W. L. Badger, 309 S. State St., Ann Arbor, Mich.

Liquid Metals in Chemical Industry

Four copies of 100-300 word abstracts indicating as many conclusions and quantitative results as possible, due by May 1, Complete manuscripts invited by deadline even without previous abstract.

CHAIRMAN: C. F. Bonilla, Dept. of Chem. Eng., Columbia U., N. Y. 17, N. Y.

Deadline—July 27, 1955

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■ **LOS ANGELES, CALIF.**

Feb. 26-29, 1956. Statler Hotel.

TECHNICAL PROGRAM CHAIRMAN: T. Weaver, Proc. Eng., The Fluor Corp., Ltd., Box 7030, East L. A. Station, Los Angeles 22, Calif.

Deadline—Oct. 26, 1955

■ **NEW ORLEANS, LA.**

May 6-9, 1956

TECHNICAL PROGRAM CHAIRMAN: H. E. O'Connell, Assoc. Dir. Process Div., Sect., Ethyl Corp., Box 341, Baton Rouge, La.

■ **PITTSBURGH, PA.**

Sept. 9-12, 1956

TECHNICAL PROGRAM CHAIRMAN: Carl C. Monrad, Carnegie Institute of Technology, Pittsburgh, Pa.

■ **ANNUAL—BOSTON, MASS.**

Dec. 9-12, 1956. Hotel Statler.

TECHNICAL PROGRAM CHAIRMAN: W. C. Rousseau, Proc. & Sales Eng., Badger Mfg. Co., 230 Bent St., Cambridge 41, Mass.

Deadline—August 9, 1956

■ **SEATTLE, WASH.**

June 9-12, 1957. Olympic Hotel

■ **ANNUAL—CHICAGO ILL.**

Dec. 8-11, 1957. Conrad Hilton

■ **CINCINNATI, OHIO**

Dec. 7-11, 1958. Netherland Plaza Hotel

TECHNICAL PROGRAM CHAIRMAN: T. B. Wiehe, Schenley International, Inc., 26 E. 6th Street, Cincinnati 2, Ohio.

UNSCHEDULED SYMPOSIA

Extraction of Hydrocarbons for Chemical Use from Pipeline Gases

CHAIRMAN: E. E. Frye, J. F. Pritchard & Co., 210 W. 10th, Kansas City 5, Mo.

Fundamental Mechanisms in Boiling Cavitation and Condensation

CHAIRMAN: R. R. Hughes, Shell Development Co., Emeryville, Calif.

Distillation Computation Methods

CHAIRMAN: Wayne C. Edmister, California Res. Corp., Richmond, Calif.

■ **NEWARK, NEW JERSEY**

May 10, 1955. Hotel Essex.

Sixth Annual Chemical Engineering Symposium of New Jersey Section, A.I.Ch.E.

FOR INFORMATION CONTACT: J. N. Whelan, Dupont Co., Parlin, New Jersey.

■ **BERKELEY, CALIF.**

June 17, 1955 U. of Calif.

One-day symposium on waste disposal sponsored by Northern Calif. Section, A.I.Ch.E.

FOR INFORMATION CONTACT: T. E. Drisco, 2990 Boni Facio St., Concord, Calif.

■ **CLEVELAND, OHIO**

Dec. 12-17, 1955. Cleveland Auditorium.

EJC Nuclear Eng. & Science Congress

PROGRAM CHAIRMAN (A.I.Ch.E.): W. K. Woods, General Electric Co., Richland, Wash.

Liquid Metals in Nuclear Power

CHAIRMAN: C. F. Bonilla, Dept. of Chem. Eng., Columbia U., N. Y. 17, N. Y.

(*Continued on page 82*)

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COMPANY_____

STREET_____ CITY_____ STATE_____

FUTURE MEETINGS

(*Continued from page* 81)

AUTHOR INFORMATION

Submitting Papers

Members and nonmembers of the A.I.Ch.E. who wish to present papers at scheduled meetings of the Institute should follow the following procedure.

First, write to the Secretary of the A.I.Ch.E., Mr. F. J. Van Antwerpen, American Institute of Chemical Engineers, 25 West 45th Street, New York, requesting three copies of the form "Proposal to Present a Paper Before the American Institute of Chemical Engineers." Complete these forms and send one copy to the Technical Program Chairman of the meeting for which the paper is intended, one copy to the Assistant Chairman of the A.I.Ch.E., Program Committee, address at the bottom of this page, and one copy to the Editor of Chemical Engineering Progress, Mr. J. B. Mellecker, 25 West 45th Street, New York.

If you wish to present the paper at a particular symposium, request 4 copies of the proposal sending a copy to the Chairman of the symposium.

Before Writing the Paper

Before beginning to write your paper you should obtain from the meeting Chairman, or from the office of the Secretary of the A.I.Ch.E. at 25 West 45th Street, New York, a copy of the A.I.Ch.E. Guide which covers the essentials required for submission of papers to the A.I.Ch.E. or its magazines.

Copies of Manuscript

Five copies of each manuscript must be prepared. For meetings, one should be sent to the Chairman of the symposium, and one to the Technical Program Chairman of the meeting at which the symposium is scheduled. If no symposium is involved, the two copies should be sent to the Technical Program Chairman. The other copies should be sent to the Editor's office. All manuscripts submitted to the A.I.Ch.E. Editor are automatically considered for C.E.P., the A.I.Ch.E. Journal, and the Symposium Series. Presentation at a meeting is no guarantee that manuscripts will be accepted.

Chairman, A.I.Ch.E. Program Committee

George Armistead, Jr., George Armistead & Co.,
1200 18th St., N.W., Washington, D. C.

Assistant Chairman

L. J. Coulthurst, Foster Wheeler Corp.,
165 Broadway, New York 6, N. Y.

NORTHERN CALIFORNIA ONE-DAY MEETING PROGRAM

The Northern California Section of A.I.Ch.E. is sponsoring a one-day symposium on Waste Disposal, to be held June 17, 1955 at the University of California at Berkeley.

PROGRAM—"WASTE DISPOSAL"

WASTE DISPOSAL IN NORTHWEST REFINERIES; T. A. Dungan, Bechtel.

BIOLOGICAL TREATMENT; H. B. Gotaas, Univ. of Calif.

INSTRUMENTATION FOR WASTE DISPOSAL; W. N. Greer, Leeds & Northrup.

LIQUID-LIQUID AND LIQUID-SOLID SEPARATIONS; A. A. Kalinske, Infilco.

(*Continued on page* 87)

BIN-FLO AERATING UNIT

STATE OF THE INSTITUTE

A test run of Spencer's Orange, Texas polyethylene plant was begun the evening of February 21st. The operating section was started up and placed in automatic control 15 minutes after initial production. Since startup, operation has been continuous. In the initial run, conditions of operation were varied to produce several satisfactory grades of product. During this period, the producing section was held to 80% of design capacity.

As the process information used for design was obtained from I.C.I. of England, that firm supplied, for the period of startup, eight experienced technicians. Many of Spencer's plant operating technicians were said to have received training in England.

Hidalgo Chemical Company will be the name for the former Carthage Hydrocol, Inc., Brownsville, Texas subsidiary of Stanolind Oil and Gas Company. R. W. Greeff & Company, Inc., of New York will act as exclusive sales agent for Hidalgo's chemical products, as they become available late this year. At present, rehabilitation of the synthesis plant is under way. Chemicals produced include acids, alcohols, aldehydes and ketones in the C_1—C_5 range. Stanolind will operate its own chemical recovery plant and the storage terminal acquired from U. S. Industrial Chemicals Company. Design capacity of Brownsville will be 125 million pounds of chemicals per year. The synthesis plant's gas requirements will be supplied from fields in Hidalgo County, Texas, which adjoins Cameron County where the plant is located.

The Texas City Works of Monsanto's Plastics Division is now producing polyethylene commercially, although not at full capacity level. The process used is based on high pressure, although a low pressure process is under study. Principal advantages expected of the low pressure product are higher heat distortion permitting sterilization and higher strength.

A new design engineering and construction organization, the Poole-Pritchard Co., Ltd., has been formed with offices in Edmonton, Alberta, Canada. The company's area of operations will be in western Canada from the Great Lakes to the Pacific. The organization is a combination of the Poole Construction Co., Ltd. of Edmonton, and J. F. Pritchard & Co. of Kansas City, Mo.

DuPont's "Elastomers Division" will be the new name for the 32-year-old "Rubber Chemicals Division."

Quality Fabrication is our Business
Whether its a kettle, reboiler, reactor or other process equipment, Manning & Lewis engineers and craftsmen are ready to design and fabricate a unit, tailor-made to fit your particular process need, and priced to fit your budget.
You need only supply the performance requirements. An experienced M & L engineer will take it from there and specify type, size, method of construction, etc.—all the essentials that have made Manning & Lewis equipment preferred in plants from coast to coast.
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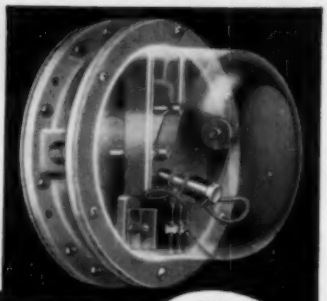
BIN-FLO AERATING UNIT

Provides Steady Flow of Dry, Finely Ground Materials which tend to bridge in storage. Uses only small amount low-pressure air.

BIN-DICATOR BIN LEVEL INDICATOR

For All Bulk Materials

signals change in level; automatically starts and stops filling and emptying equipment.



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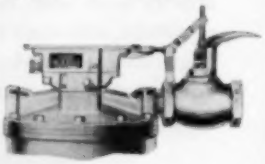
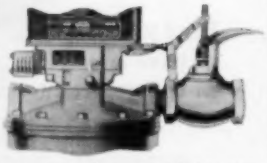


Delivers predetermined quantities up to 10,000 gallons, then shuts off.



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STATE OF THE INSTITUTE

(*Continued from page* 48)

United Engineering Trustees—and it will take a good deal of time and much patience, I'm sure, to work out a satisfactory basis on which we can cooperate and enter into this venture with them. All I can report at this time is that it's being studied.

We have recently undertaken a new venture in the publishing field. You all are familiar with *Chemical Engineering Progress*, and now we are branching out with another Journal which is to be devoted entirely to the more technical, more theoretical phases of chemical engineering. The first issue is already in the hands of approximately 3000 subscribers. This points up the fact that we have some financial problems. A new Journal of this type will not be self-supporting—it's going to cost us many thousands of dollars each year. Furthermore, the cost of our other activities has gone up like everything else. We also have plans for rendering better service in many fields.

All this adds up to the fact that we have a need for more income. I want to tell you about one proposal which is now under serious consideration by the Council and that is a small increase in the dues. What we have in mind at the moment (although it may change), is an increase of about one sixth. Those who are now paying $18 a year would be paying $21; those paying $12 would be paying $14. I believe it is fair to say that our dues at the present time are low compared to the dues of most other comparable societies.

Now the answer to this problem is membership—the more members we have the better service we can render on the basis of greater income. But it's not only that. We want to be truly representative of the chemical engineering profession. At the present time not more than about 30% of all chemical engineers in the country are members of the Institute. I don't want to give the impression that we are far behind others, I think this percentage is more or less the same with the other engineering societies as well, but we can do better than that. Furthermore, we get as members at the present time only a relatively small percentage of the new chemical engineers—the graduating students—as they leave school.

We believe that we have much to offer, and that in the long run membership in an organization such as this is a good investment. We hope to do something about this by aggressive campaigns during the coming year.

BARNETT F. DODGE
President, A.I.Ch.E.

A special undergraduate course to provide a background in the fundamentals of nuclear engineering will be offered students in the College of Engineering at Ohio State this spring.

The course includes the necessary basic nuclear physics and the primary elements of reactor technology. It will be presented jointly by C. E. Dryden of the Dept. of Chemical Engineering, and J. N. Cooper of the Dept. of Physics, with other members of the Engineering faculty.

The University of Michigan is offering eleven intensive courses varying in length from three days to two weeks for practicing engineers. Among those of possible interest to chemical engineers are (including dates and fees) : Gas turbines & free piston engines, June 13-17, $100; Flow of natural gas from reservoirs, June 20-July 1, $125; Automatic control, June 13-18, $125; also June 20-22, $60; Small particles & suspensions, July 6-16, $125; Structures & properties of high polymers in solution, July 18-23, $125; Digital computers & data processors, Aug. 1-12, $160; Nuclear reactors & radiation in industry, Aug. 15-26, $200. For further information contact Professor D. L. Katz.

The 10th Purdue Industrial Waste Conference will be held May 9 through 11 in the Memorial Union, at Lafayette, Ind. Approximately fifty papers will be presented. Further information can be had from D. E. Bloodgood, Professor of Sanitary Engineering, Purdue Univ.

Cornell University will again give their Summer Course in Techniques and Applications of the Electron Microscope, from June 13 to 25, 1955. It will be under the direction of the Laboratory of Electron Microscopy in the Dept. of Engineering Physics. Further information is available from Professor B. M. Siegel.

Twenty-five students, carefully selected from junior classes of major accredited engineering colleges on the basis of talent and promise, will be given graduate level work at Rensselaer Polytech during the summer months for the purpose of determining whether such students can be accelerated in their training.

Courses on metals will be given May 9, 10 and 11 by the School of Mechanical Engineering at Oklahoma A. & M. College. Persons interested should contact Professor B. M. Aldrich.

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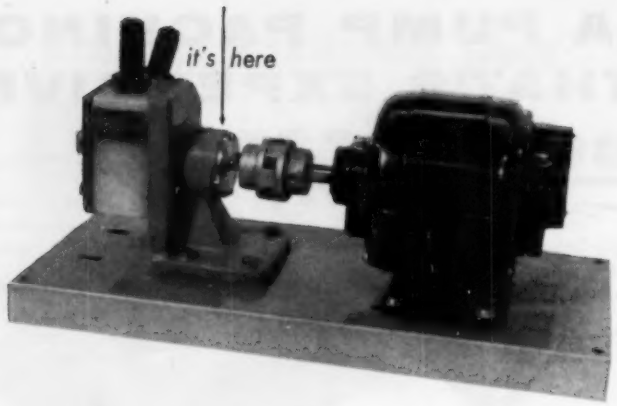

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The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on admissions.

These names are listed in accordance with Article III, Section 8, of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members will receive careful consideration if received before May 15, 1955, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

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Achorn, Glenwood B., Jr., *Camp Detrick, Md.*
Blunt, Paul, *Joliet, Ill.*
Carroll, F. M., *Newell, Pa.*
Corona, Edward J., *Port Allen, La.*
Eudaley, Glenn R., Jr., *Port Arthur, Tex.*
Furbush, S. A., *Hopewell, Va.*
Goodwin, A. W., *Texas City, Tex.*
Harrison, Richard H., *Port Marion, Pa.*
Hennig, Harvey, *Crystal Lake, Ill.*
Hill, Frederick J., *Wallingford, Pa.*
Hudson, Robert B., *Trenton, Mich.*
Kassay, Andrew W., *Toledo, Ohio*
Keary, William V., *East Bridgewater, Mass.*
Ludwig, Ernest E., *Lake Jackson, Tex.*
McMillan, Donald, *Hammond, Ind.*
Megruil, George G., *Hopewell, Va.*
Perris, George, *Montreal, Que., Canada*
Pomeroy, G. W., *Glendale, Ohio*
Shepherd, George R. L., *Baytown, Tex.*
Snell, Chester A., *New York, N. Y.*
Stell, Robert C., *Akron, Ohio*
Stretton, Thomas E., *West Roxbury, Mass.*
Tobey, Richard S., *Wilmington, Del.*
Topsoe, Haldor, *Hellerup, Denmark*
Wilson, Frank W., *Baltimore, Md.*
Wiseman, James V., *Westend, Calif.*

Associate

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Bays, Harold C., *Richmond, Va.*
Butler, Robert F., *Hopewell, Va.*
Cohen, Raymond Gene, *Fort Monmouth, N. J.*
Collins, Arthur S., *Cambridge, Mass.*
Comolli, Alfred G., *Westerly, R. I.*
Dean, Robert L., *West Orange, N. J.*
D'Ianni, J. D., *Akron, Ohio*
Dwyer, James L., *Glenolden, Pa.*
Eckert, Roger E., *Wilmington, Del.*
Emmert, Richard E., *Sheffield, Ala.*
Evans, Thomas F., *Springfield, Mass.*
Falk, George W., *Chicago, Ill.*
Fielitz, Richard, *Irvington, N. J.*
Figh, John P., *Pensacola, Fla.*
Frennesson, Bertil J., *Naugatuck, Conn.*
Furini, Bruno, Jr., *N. Woodbury, N. J.*
Gaddy, James L., *Baton Rouge, La.*
Gentilucci, August T., *Woodbury, N. J.*
Griffin, J. Dennis, *Midland, Mich.*
Hair, Edward R., *Silver City, N. M.*
Harriott, Peter, *Ithaca, N. Y.*
Hayford, John S., Jr., *Chauncey, N. Y.*

Koffolt, Thomas J., *Columbus, Ohio*
Krusen, George C., II, *Riviera Beach, Md.*
Kuntz, Clarence I., *Woodbury Heights, N. J.*
Lattin, Clark P., Jr., *New York, N. Y.*
Layton, L. E., *Woodbury, N. J.*
Lofredo, Antony, *Astoria, L. I., N. Y.*
Lyon, John B., *Wilmington, Del.*
Maish, James A., *Whiting, Ind.*
McGrew, John Douglass, *Charleston, W. Va.*
Melnik, Peter, *Woodbury, N. J.*
Mifflin, Thomas R., *West Lafayette, Ind.*
Mohr, Clifford F. L., *Wright-Patterson Air Force Base, Ohio*
Mottel, William J., *North Augusta, S. C.*
Pavilonis, Edward J., *Racine, Wis.*
Pease, Robert N., *Detroit, Mich.*
Perrine, William E., *Baton Rouge, La.*
Pfeuffer, Paul O., *Queens Village, N. Y.*
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Watson, James W., *Lansing, Ill.*
Weinman, Charles G., *Cedar Grove, N. J.*
Whitney, James F., *Pittsfield, Mass.*
Worley, George A., *Newark, Calif.*
Yackel, D. Carl, *Rochester, N. Y.*

Affiliate

Payne, Ralph O., *Knoxville, Tenn.*

FUTURE MEETINGS

(*Continued from page 82*)

NATIONAL CAPITAL SECTION

April 25 National Press Club

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MODERATOR

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PANEL

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V. Pres., Irving Trust Co.
TOPIC: "Capital Structure"

Mr. V. R. Bechtel
Dir. of the Budget, Amer. Cyanamid Co.
TOPIC: "Day-to-Day Problems"

Mr. Newton Steers
Pres., Atomic Development Mutual Fund
TOPIC: "Participation by the Average Man"

Mr. Russell Dorr
Chief, Japanese & Indonesian Div., Internat. Bank for Reconstruction & Devel.
TOPIC: "Problems Posed by International Boundaries"

(*Continued on page 99*)

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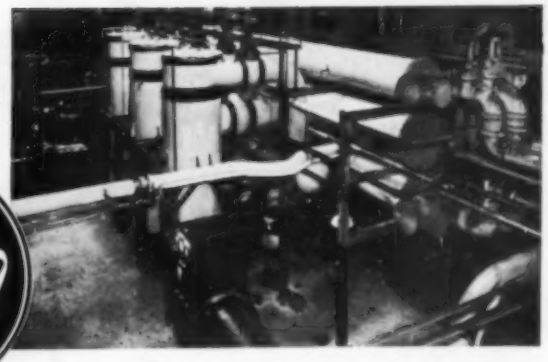

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News of the Field

FROM LOCAL SECTIONS

Knoxville-Oak Ridge. The importance of the statistician as a major assistant to the engineer in designing a shorter, more direct experimental program for obtaining optimum conditions in chemical processes was shown by A. W. Kimball speaking at the February 23 meeting of the Knoxville-Oak Ridge Section.

By using "the method of steepest ascent" the statistician can provide much needed help, but the statistician is no "cure-all' and cannot make good data from bad. It is up to the engineer to furnish the facts of the experiment, say what he is trying to find, indicate the limitations proposed and the variables to be considered.

To illustrate how the engineer can make the job of the statistician easier, Kimball pointed out that the number of variables in any given problem can often be reduced since two variables may be basically related to each other and could be expressed as a single variable when given to the statistician.

To support his contention that the statistician can assist in both the speed and accuracy of solving these problems of optimum conditions, Kimball discussed the faults of a commonly used method to determine optimum conditions. With this, and other methods, Dr. Kimball said, it is possible to spend a great deal of time and still have an erroneous solution. The statistician could solve this by using his own statistical tools for the engineer.

The new officers for the year are: chairman, H. F. Johnson, University of Tennessee; chairman-elect and program chairman, R. N. Lyon of Oak Ridge; secretary and treasurer, E. F. Martin, Jr., and W. S. Lenihan, Jr.

—R. J. McNamee

St. Louis, Mo. The engineering aspects of ion exchange came in for discussion at the January meeting of the St. Louis Section.

The speaker, J. T. Roberts of the Chemical Technology Division of Oak Ridge National Laboratory, a veteran in the field of ion exchange problems, discussed the relationship of ion exchange on an engineering scale to the unit operations of fluid flow in packed beds, separation by mass transfer, solid-liqiud extraction, and adsorption.

At the same meeting Mr. F. J. Van Antwerpen, Institute secretary, spoke to the student chapter at Washington University on the vital subject of the "why" of professionalism.

—Aaron Rose

News of the Field

FROM LOCAL SECTIONS

Charleston, W. Va. Smoke screens may prove to be a valuable defense in reducing the effects of nuclear explosions according to Maj. Gen. W. M. Creasy, the Army's Chief Chemical Officer, speaking before the Charleston Section during National Engineers' week.

Creasy explained that an adequate smoke screen in the area of a major bomb burst could result in a tremendous reduction in casualties and fires in the brief period of intense heat radiation. He warned, however, that smoke is not a defense against radioactive radiation.

Suitably located pulse-jet generators can cover an area with a protective smoke screen in 10 to 15 minutes. With additional help of properly located industrial furnaces aided by prevailing winds, and the classical smoke pots, smoke screens extending 1000 to 2000 feet from the ground could contribute to the reduction of heat penetration from an overhead explosion to the point of preventing most ground fires.

Detailed study of the effects of smoke screens are being carried on in current Nevada tests with nuclear weapons, Creasy said.

—R. W. TIMMERMAN

Atlanta, Ga. A captured German film on V-2 rocket firing, and special slides, illustrated a talk on rockets and guided missiles, the propellants and firing action of each, given by Joseph C. Cox, deputy chief of the Redstone Arsenal Rocket Development Laboratory, Ala., at the February meeting of the Atlanta section.

In cooperation with high schools, some members will offer counselling to students interested in entering the field of engineering. Science Fairs are being planned in various sections of Alabama which will attract the interest and efforts of the A.I.Ch.E. group.

—H. H. SINEATH

Rocky Mountain. New glass-lined equipment to meet new uses was the major topic of interest at the March 3d meeting of the Rocky Mountain Section.

The new equipment, disclosed by E. W. Neben, Chief Process Engineer and Manager of the Chemical Equipment Sales Division of the Pfaudler Company, includes a tumble-type vacuum dryer, glass-lined tube and shell heat exchangers, and a new distillation column.

Neben, in mentioning these products, described the process of manufacturing glass-line equipment, and the difficulties involved.

—R. M. BERRY

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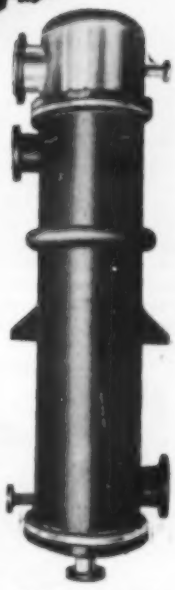

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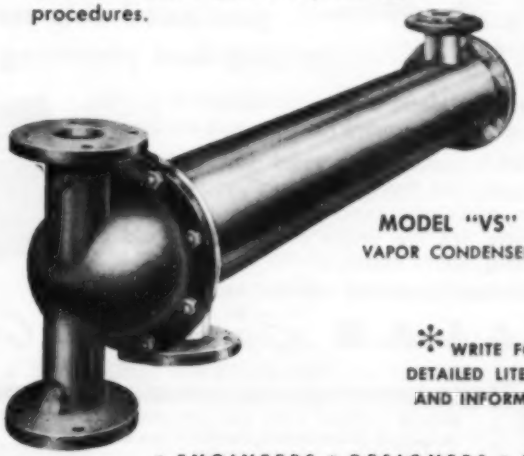

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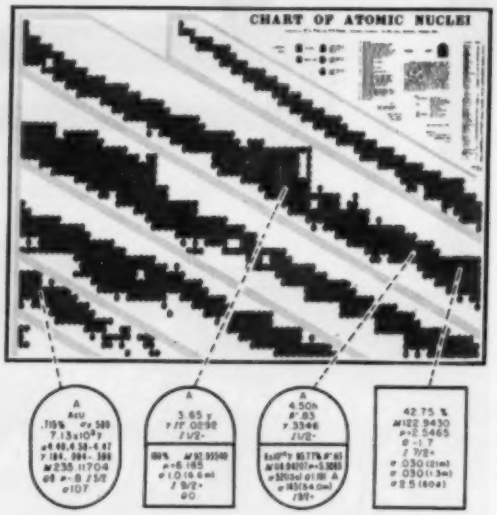

Prepared by: M. L. Pool, Professor, and D. N. Kundu, Assistant Professor, Department of Physics and Astronomy, The Ohio State University.

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A.I.Ch.E. News of the Field
FROM LOCAL SECTIONS

Southern California. The controversial problem of professional unionism was considered at the February meeting of the Southern California Section.

Should engineers belong to a professional union, a real labor union, is the essence of the question raised at the meeting. Principal speaker, W. J. King took the side that they should and an active discussion developed.

The assistance being rendered by Engineers Joint Council, in bringing to attention the problems of the engineer in attaining a higher professional status in the eyes of his fellows and the general public, was acknowledged.

The importance of the whole question relating to the professional status of the engineer was considered so great that future meetings on the subject are planned.

—Frederick G. Sawyer

Tennessee Valley. A demonstration of how the thrust of solid propellant rocket-type boosters can be "programmed" within relatively wide limits by the proper choice of propellant charge geometry was presented by H. W. Ritchey, technical director, Redstone Division of Thiokol Chemical Corporation, to the Tennessee Valley Section at its February 24th meeting.

Propellant charge geometry, Ritchey explained, determines the amount of surface burning at each instant which in turn determines the time-thrust relationship. Slides illustrated some of the shapes designed for specific purposes, such as a "cog-wheel" shape which gives two levels of thrust, and a seven-perforated internal burning cylinder which is extremely progressive.

Ritchey emphasized that a solid-propellant thrust unit is a stable-operating device based on sound principles of fluid mechanics and that great flexibility exists in the choice of thrust program depending on the choice of configuration and propellant.

—Garnett L. Wade, Jr.

Rochester, N. Y. Some of the capabilities and limitations of plastics as a material of construction were pointed out by R. B. Seymour, president of Atlas Minerals Products Company at the February 16th Meeting of the Rochester Section.

Seymour's remarks, commenting on the more than 200 slides shown during his talk, dealt with the practical and specific applications of plastic fabricated or coated articles.

—J. A. Mason

News of the Field
FROM LOCAL SECTIONS

Baltimore, Md. Many problems face the engineer before economical nuclear power will be available. This was the crux of a discussion of "Energy Resources" presented by A.I.Ch.E. president Barnett F. Dodge at the annual Senior Guest Dinner Meeting of the Maryland Section on February 15.

"In fact," Dodge said, "it is possible that, except under unusual circumstances, nuclear power may never be able to compete successfully with presently available sources of energy." Nuclear power will probably never be "cheap" power as compared to present sources, but will depend for its extended use on situations where package power, or the unavailability of other types of power, will make its use attractive.

Solar energy, another possible new source of power, is also facing difficulties in practical utilization, Dodge continued, with space heating, because of the low temperature differentials required, offering the best chance of more immediate use of direct sun heat.

—Charles G. Schmitz

Chicago, Ill. Free trade will not lead to an increased world standard of living but to a simple redistribution of income in the world today, according to L. E. Lloyd, economist of Dow Chemical Co., in a talk before March 9th meeting of the Chicago Section.

Lloyd bases his opposition to the numerous advocates of free trade on the fact that the major premise of the free-traders is not true. This premise is that all conditions other than *natural advantage* are equal. In the present day world many unnatural differences exist and thwart the advantages claimed for free trade. To give the higher standard of living claimed, free trade would require uniform taxes, a universal currency, uniform business laws and regulations, a common business ethic, equal wages, freedom from labor migration, and a guarantee there would be no more wars. All of these are highly unlikely.

Free trade as it would operate today, Lloyd insists, would bring only lower wages and unfair competition to this country.

—S. O. Sourelis

Baton Rouge, La. The third meeting for 1955 of the Baton Rouge Section was held on March 14th. Forty-one members and guests were in attendance.

C. L. Fleming, Jr., Director of the Products Research Division of Esso Research and Engineering Company, was the speaker. Fleming spoke on "Combustion Chamber Deposits in Automotive Engines."

—K. A. Rees

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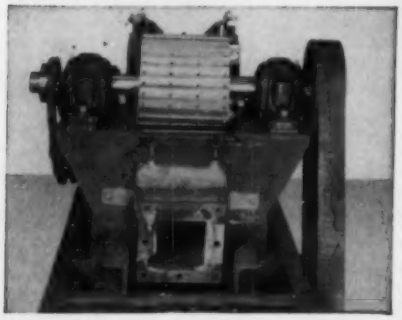

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A.I.Ch.E. News of the Field
FROM LOCAL SECTIONS

Pittsburgh. Awards to two aspiring engineers of the Pittsburgh area, and a talk by Institute secretary F. J. Van Antwerpen on "What Makes a Professional Engineer," highlighted the annual Student Night Meeting of the Pittsburgh Section held on March 3.

The awards, given to the two senior students in local universities who submitted the best written reports on Unit Operations, were made for the first time and went to C. F. Gaertner of West Virginia University and J. A. Frayer of the University of Pittsburgh. Each award included books of the student's own selection and a year's subscription to *Chemical Engineering Progress.*

—H. B. Coats

Central Ohio. A twenty-minute film showing the stress corrosion cracking of a magnesium base alloy in salt chromate solution was seen by members of the Central Ohio Section at their February 22nd meeting at Ohio State University.

The film, recognized as an outstanding contribution to the study of stress corrosion, was shown and narrated by F. H. Beck, assistant director of Ohio State's Corrosion and Research Laboratories. Prior to the film, Beck explained stress corrosion to the membership, and indicated how anodic protection can lessen or eliminate such corrosion.

—John W. Salter

Terre Haute, Ind. Prospective engineers travelled a hundred miles to attend the Terre Haute Section's February 22nd panel discussion of standards and conditions facing the engineering student looking for his first job.

The panel consisted of Homer Keiweg, manager of biochemical production, Commercial Solvents; C. L. Wrenshall, head of technical service, Pfizer; J. Momier, assistant plant manager, Dana Plant, DuPont; R. S. Pierce, chief engineer, Visking Corp., and Roy Taylor, manager of chemical research and development, Pfizer. The meeting was kept active by the unusually large number of student questions.

In addition, the Terre Haute Section announced the formation of a new public relations committee on television activities. The Section has been particularly active in this field for some time, with special shows and panel discussions going on the air. —Fred W. Schmitz

NEWS from FILTERTOWN

Extremely versatile E&D #613 is equally at home in the laboratory and the industrial plant.

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the chemical engineer in

MARKETING

Union Asbestos & Rubber Co. names **Frank B. Kreider** general sales manager of its fibrous products division.

In addition to engineering degrees from Carnegie Tech and the U. of Pittsburgh, Kreider takes over his new position with Unarco after experience as general sales manager of the Darling Valve and Manufacturing Co., Williamsport, Pa.

L. P. Wenzell transfers to new position as manager of special industrial development in the market development department of the textile division of Celanese Corp. of America.

Hercules Powder Co. announces appointments in the Paper Makers Chemical Department: **P. F. Neumann,** manager of rosin size sales; **Thomas S. Morse,** manager of sales service, paper chemicals, and **James K. Farrell,** manager of product improvement, paper chemicals.

Two product engineers join chemical sales department of B. F. Goodrich Chemical Co.: **L. L. Shailer, Sr.,** takes charge of sales development of hydrophilic polymers and **R. E. Score, Sr.,** assumes similar duties with surfactant materials.

J. S. Wolff is biochemical sales development manager of the general chemical sales department of the company.

Paul B. Geiser promoted to position of market development representative in petrochemical department of Continental Oil Company. He will headquarter in Houston.

Robert R. Pierce, sales manager of the corrosion engineering products department, Pennsylvania Salt Manufacturing Co., joins board of directors of National Assoc. of Corrosion Engineers.

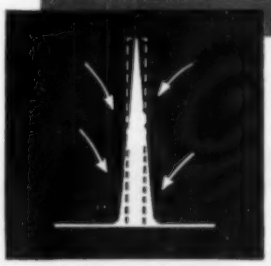
Ivan Y. T. Feng, Robert M. Henderson, and **James B. Smith** join market research department of American Cyanamid as senior market research analysts.

Philip G. Connell, Jr., is manager of rubber chemicals sales of the company.

(*Continued on page* 94)

Even More Surface
per sq. ft. of face area
Even Less
Air Friction

with the New AEROFIN Type B
Smooth-Fin Heat Exchangers



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the chemical engineer in

MARKETING

(*Continued from page 93*)

William E. Mydans appointed vice-president and technical director of George Black Co., New Jersey.

Mydans assumes his position with a doctorate in chemical engineering from Harvard plus years of experience as chemical and industrial product consultant, and representative for one of Italy's largest chemical companies, and as director of packaging development and new product research for Olin Industries.

He will head industrial public relations, management and marketing counsel at George Black.

W. D. Willes advances to position of product manager of Nordstrom Valve Div., Rockwell Manufacturing Co. in Pittsburgh.

Willes' appointment begins a program to expand and centralize the Nordstrom sales division.

Republic Flow Meters Co. promotes **Ralph E. Holmes** to district manager of Philadelphia office. **Sten Hammarstrom** succeeds Holmes as manager of Cincinnati district offices.

Albert W. Dunning* appointed to direct newly-created marketing department at Shawinigan Resins Corp.

The new department will handle development and technical service and sales of the company's vinyl resins line.

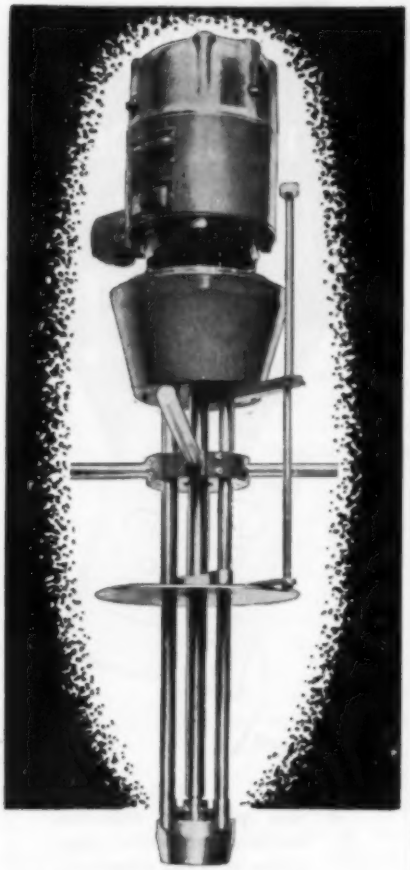
Ben H. Loper, technical representative of the refinery chemicals department of American Cyanamid Company, will cover the territories of the firm's Houston, Tulsa and Los Angeles sales offices.

Ronald L. Clark directs the study and analysis of markets for new products as supervisor of market research and development for Brea Chemicals, Inc., Brea, Calif.

Mr. Clark comes to Brea from the position of assistant director of market research for the Vick Chemical Company in New York.

William H. Winemiller replaces **Kenric H. Bird** as assistant sales manager of the refractories division of the Norton Company. Mr. Bird has retired after 27 years with the company.

William A. Meiter advances to position of general sales manager of the Worthington Corporation, Harrison, N. J.



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people IN MANAGEMENT AND TECHNOLOGY

W. Kenneth Davis, pictured below, is appointed director of reactor development for the Atomic Energy Commission succeeding **L. R. Hafstad,** who recently resigned from his AEC post to join the Chase National Bank of New York as atomic energy consultant to the bank's industrial customers for the furtherance of peacetime uses of atomic power.

With his new position, Davis assumes as his duties the direction of AEC's programs for nuclear reactor development in naval and aircraft propulsion, and military and civilian stationary power.

In addition, Davis will direct programs encouraging private industry and public organization to join in reactor development and related electric power production.

With a M.S. degree in chemical engineering from M.I.T., Davis comes to his new position with experience as deputy director of the AEC reactor development division, U. of California professor, manager of research for the California Research & Development Co., and as senior research engineer for a New York engineering firm.

Esso Research and Engineering Co. announces **John K. Darin** as new addition to the company, and **Donald D. Dunlop** as new member of petroleum development division.

Dunlop received his doctorate in chemical engineering from A & M College of Texas.

Darin is presently working toward a doctorate degree from the U. of Pittsburgh where he had earned his bachelors and masters degrees in chemical engineering.

Boleslaw Sienkiewicz promoted to project leader in engineering research at Central Labs of General Foods.

He is a chemical engineering graduate of Brooklyn Polytech.

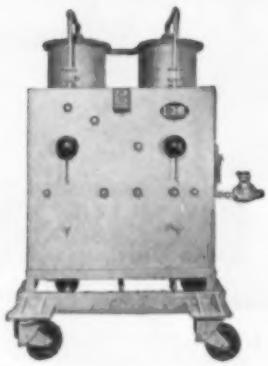
William P. Drake appointed executive vice-president of Pennsylvania Salt Manufacturing Co.

John Van Vessem, chemical engineering grad from Case Institute of Technology, joins operations department of Hooker Electrochemical Co.

(*Continued on page* 96)

ILLCO-WAY

ionXchange



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With this new unit, you can do your deionizing wherever you want to, because the "wagon" is completely self-contained and fully portable. We have made a number of similar arrangements for various specific purposes (such as the recovery of chromic acid from each of a string of plating tanks) but this is a *general-purpose* unit, primarily for the demineralization of water, but adaptable to other uses as well. It is available in either Two-Bed or Mixed Bed models.

PROVIDES DE-IONIZED WATER WHERE AND WHEN YOU WANT IT

Operation is simple. You pull the unit right up to the most convenient location, hook up inlet and outlet hoses or pipes, run the process as long as needed, disconnect the unit, and haul it away to the next job. Regeneration is accomplished at some central point where a drain is handy and regenerant can be stored. *If something like this has a place in your plant, please write for further details.*

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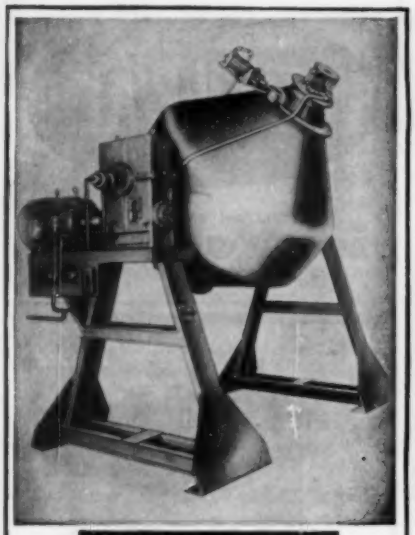

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people IN MANAGEMENT AND TECHNOLOGY

(*Continued from page 95*)

John A. Scott is elected president of Sinclair Chemicals, Inc., subsidiary of Sinclair Oil Corp.

Scott takes over the post from his previous position as executive vice president and as a director of the company, having been with Sinclair Chemicals since its organization in 1952.

Joining the Sinclair organization in 1934, Scott has been research technologist, manager of the petrochemicals division, and serves now as director of Sinclair Research Labs and Calumet Nitrogen Products Co.

He is a chemical engineering graduate of the U. of Minnesota.

Dwight C. Brown is appointed senior process engineer in the research and development department of the Jones & Laughlin Steel Corp.

Brown will work with coal chemical operations, industrial waste problems and process developments involving lean ore.

Clifford L. Sayre, chemical engineer for Becco chemical division of Food Machinery & Chemical Corp., achieved the rank of brigadier general in the Army Chemical Corps. He is the first reserve officer to earn this commission.

J. L. McCurdy is promoted to assistant manager of the plastics production department of Dow Chemical Co. He will have charge of Styron, saran, Ethocel, vinyltoluene and polyvinyl chloride operations at the Midland division.

Succeeding McCurdy as manager of the Torrance, Calif. Styron plastic plant is **Daniel W. Ryan.**

Continental Oil Company announces **Robert L. Kylander** as staff engineer in the petrochemical department, Houston.

Newly appointed, also, was **Robert E. Maples** as process and sales service engineer succeeding Kylander in Baltimore. Both men are graduate chemical engineers.

American Cyanamid names **M. N. Gaboury** manager of manufacturing for the organic chemicals division, and **F. B. Manker** manager of the company's Bound Brook, N. J. plant.

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General Aniline & Film Corp. names **Joseph W. Lang** manager of manufacturing for the dyestuff and chemical division.

Joining GAF in 1943 with research and chemical engineering experience at Dupont, Lang served as manager of GAF's Rensselaer plant and was in charge of the company's research labs in Easton, Pa., in the capacity of research director.

Lang earned his Ph.D. from Columbia U., having taken his undergraduate work at the U. of Washington.

Monsanto Chemical Company names three to new posts: **John F. Thompson,** with Monsanto since 1946, as superintendent of maintenance and engineering services for inorganic manufacturing facilities at the William G. Krummrich plant; **J. W. Haun** as group leader in the plastics division of the company; and **James C. Johnson** as production superintendent at the Norfolk, Va., plant.

Linde Air Products Co., division of Union Carbide & Carbon Corp., announces **R. S. Abrams** plant manager of the new silicones plant in W. Va.

J. J. Doub named superintendent of production, and **G. M. Fowles,** plant engineer.

With 16 years' experience in the company, **Abbott Byfield** is named director of development in the research and development department of Kimberly-Clark Corp., Wis.

Tellepesen Petro-Chem Constructors of Houston, Tex., announce **Howard K. McLaughlin** as assistant chief engineer of this company, a division of Tellepsen Construction Co.

Robert S. Miller joins chemical engineering department in Emeryville, Calif. labs of Shell Development Co.

The company announces also, the addition of **Howard L. Hassel** to staff of Emeryville Research Center.

Frank B. Huke appointed chief atomic products engineer in the refractories division of the Norton Company.

Charles O. Koch is appointed technical service superintendent at the new isocyanate plant.

Lucian L. Morgan promoted to research engineer in the process control department in the Convair division of General Dynamics.

(*Continued on page* 100)

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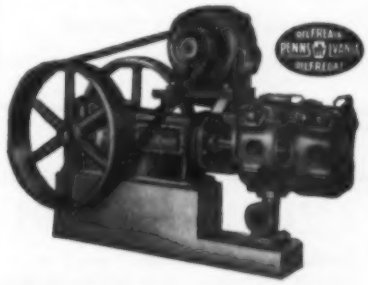

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Midwestern chemical plant, producer of materials for the AEC, requires experienced estimator for construction and major maintenance projects. Please submit complete résumé of personal data, education, previous experience, salary received, and references. All replies will be treated in confidence.

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CHEMICAL ENGINEER—Recently built, modern mill, processing non-metallic ores, in Northern New York State has opening for assistant mill superintendent for graduate chemical engineer, who has had minimum six years' experience in field, preferably with some experience in power generation or steam plant operation. Reply giving references, résumé of education and experience, and salary expected. Box 4-4.

CHEMICAL ENGINEER—Up to three years' experience in chemical pilot plant operation, to operate pilot plant units, collect data for process development, and synthesize pilot quantities of polymers. This is a permanent position in Celanese's modern research laboratores in Summit, New Jersey, a pleasant residential community within thirty miles of metropolitan New York City. Please send complete résumé, including salary desired, to Mr. J. A. Berg, Celanese Corporation of America, Summit, New Jersey.

INSTRUCTORSHIP IN CHEMICAL ENGINEERING—Recent M.S. preferably with some industrial experience, for September vacancy at small top ranking engineering college. Will permit arrangement leading to Ph.D. Send qualifications, including courses and grades, and references to Box 7-4.

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PROJECT ENGINEER—P.E. Cost estimates and construction proposals prepared for selected processes in organics, fats, oils, detergents, and pharmaceuticals. Flowsheets and layouts. Northeast. Box 1-4.

CHEMICAL ENGINEER — Fourteen years' process-project experience including process and equipment application, design and layout. Authority high temperature heating systems and allied equipment. Some administrative and sales engineering experience. Desire position leading to administrative responsibility. Age 38. Available with notice. Box 6-4.

CHEMICAL ENGINEER—B.S. 1937. Diversified experience in heavy chemical and petroleum, design, process design, instrumentation, some production and sales. Presently employed in engineering supervisory capacity. Desire position with future in supervision or administration. Box 8-4.

STYMIED—Looking for greater opportunity in the Southwest with small petroleum or chemical outfit. Thirteen years' experience. Last eight years with major petroleum refiner. Last five years' supervising process design, technical service, and economics sections. Previous experience in pilot plants, major chemical company. Box 9-4.

COMMERCIAL DEVELOPMENT—Experienced chemical engineer, Masters Harvard Business School June 1955, wants organization that can capitalize on imagination, new product and appliance ideas, or has experimental, production or development problems and can utilize administrative capacities, offer increasing responsibilities. Box 10-4.

LIQUID OXYGEN PRODUCTION — Seven years' process-project engineering; ten years' heavy experience in design and sale chemical process equipment. Graduate degrees; publications. Seek responsible position in engineering development, or equipment sales. New York, New Jersey, metropolitan area preferred. Box 11-4.

TWENTY YEARS' EXPERIENCE in chemical and metallurgical industries. Pilot and full scale process engineering, cost estimation, operation, maintenance and plant engineering in electrolytic alkali-chlorine, magnesium, synthetic rubber, hydrazine, titanium and zirconium metals, ferro-alloys, chemicals, ceramics and refractories. M.S.Ch.E. 1935, married, age 44. Desire position with expanding company. Salary required $10,000. Box 12-4.

CHEMICAL ENGINEER—B.S.Ch.E., 1952, age 25, married. One years' process development in organic chemicals. Separating from Army, July 1955, after two years as Ch.E. at Army Chemical Center. Prefer Upper Midwest. Salary desired, $6,000. Box 13-4.

EXECUTIVE ENGINEER—Experience in organization and administration, manufacturing, supervision, human relations, new plant start up, and process and product development. Strong background in building materials. Seek management responsibilities. Graduate chemical engineer. Age 33, married. Box 14-4.

CHEMICAL ENGINEER—Eleven years' diversified experience in petro-chemicals, petroleum refining, synthetic fuels, and ammonia, with emphasis on process design, economic evaluations, cost studies, and company diversification activities. Present assignment as assistant to executive at salary of $10,000 a year. Seek position with aggressive oil or chemical company. Box 15-4.

CHEMICAL ENGINEER—B.Ch.E. New York University, 1951. World War II and Korean veteran. Married, no children, age 36. Statistical quality control with a leading mechanical rubber goods manufacturer. Knowledge of compounding. Textile experience, dye application. Mechanically inclined. Desire position with opportunity and advancement. Box 16-4.

CHEMICAL ENGINEER— M.Ch.E., age 29, single, veteran. Six years' diversified experience in process equipment sales; project, process and development engineering; initial operations; production supervision. Box 17-4.

CHEMICAL ENGINEER—B.S., 1942, age 35, married. Five years' varied experience in process development, plant technical assistance, quality control and production supervision. Eight years in private enterprise. Desire West Coast. Box 18-4.

CHEMICAL ENGINEER—B.Ch.E., 1948, age 27, married, veteran. Seven years' experience in research pilot plant and production supervision, trouble shooting, sanitary engineering, and instrumentation. Versatile engineer seeking greater responsibility and increased opportunity. Box 19-4.

FOREIGN SERVICE—B.S.Ch.E., married, no children. Five years' diversified pre-degree experience with major oil company. Present position, application and sales engineer, manufacturer of process control instruments. Prefer South America chemical engineering assignment. Box 20-4.

CHEMICAL ENGINEER—B.S., 1951. Interested in statistical applications of chemical engineering such as experimental design, quality control, or market research. Desire location where schooling can be continued at night. Box 21-4.

CHEMICAL ENGINEER—Presently engaged in petroleum product development engineering. Wish responsible production work in chemical process operations with Northeastern company. Previous experience includes operation in chemical manufacturing. B.Ch.E. 1953, age 26, veteran, married. Box 22-4.

OVERSEAS — CHEMICAL ENGINEER — M.S. 1949. Five years' diversified experience here (antibiotics to industrial chemicals) and abroad (fertilizers) in project engineering, production supervision, construction and start-up work. Box 23-4.

CHEMICAL ENGINEER—Four years' varied experience, project leader, major projects: pilot plant development, process design, modification or existing processes. Six years' teaching. Ph.D., age 34, married, veteran. Desire responsible position, research and/or development, East or Midwest. Box 24-4.

EXECUTIVE CALIBER CHEMICAL ENGINEER, S.M., M.I.T., P.E. Nine years' diversified experience in development and design with two major companies. Seek career position with growing company. New York City or suburbs only. Present salary $9,000. Box 25-4.

ENGINEER FOR FOREIGN SERVICE—M.Ch.E., with three years' pilot plant and product development experience. Desire job in foreign country. Have supervised both engineers and operators. Age 26, single, citizen, veteran. Box 26-4.

CHEMICAL ENGINEER—M.S. Eight years' experience; thorough knowledge all phases process and project engineering. Capable of independently initiating and successfully concluding technical service investigations, development programs, process plant designs and economic evaluations. Wish to relocate with manufacturing company in New Jersey-Metropolitan New York area. Box 28-4.

FUTURE MEETINGS

(*Continued from page 87*)

COLUMBUS, OHIO ONE-DAY MEETING PROGRAM

Five Sections of the A.I.Ch.E. are sponsoring a one-day symposium on Industrial Gases, April 29, 1955, at the Deshler-Hilton Hotel in Columbus, O.

PROGRAM—"INDUSTRIAL GASES"

MANUFACTURE OF SYNTHESIS GAS FROM NATURAL GAS; Norman Updegraff, The Girdler Co.

DRYING OF GASES BY ADSORPTION WITH SYNTHETIC MOLECULAR SIEVE ZEOLITES; R. A. Jones & E. H. Westerland, Linde Air Products Co.

ENGINEERING PROBLEMS IN UTILIZATION OF TONNAGE OZONE; Victor Hann, Welsbach Corp.

MODERN METALLURGICAL PROCESS USES INDUSTRIAL GASES; R. B. Filbert, Jr., & G. F. Sachsel, Batelle.

HYDROCARBON REFORMING BY A NEW PYROLYTIC PROCESS; G. L. Fleming, The Koppers, Co.

LOW TEMPERATURE PROCESS FOR INDUSTRIAL GAS PURIFICATION; D. F. Baker, Air Products, Inc.

THE PREVENTION OF INDUSTRIAL GAS EXPLOSION DISASTERS; M. G. Zabetakis & G. W. Jones, U. S. Bureau of Mines.

LOCAL SECTION—PHILA.-WILM.

Apr. 12—"Industrial Explosives," Mr. Taylor, Atlas Powder Co.

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Advertisements in the Classified Section of Chemical Engineering Progress are payable in advance at 15c a word, with a minimum of four lines accepted. Box number counts as two words. Advertisements average about six words a line. Members of the American Institute of Chemical Engineers in good standing are allowed one six-line Situation Wanted insertion (about 36 words) free of charge a year. Members may enter more than one insertion at half rates. Prospective employers and employees in using the Classified Section of Chemical Engineering Progress agree that all communications will be acknowledged; the service is made available on that condition. Boxed advertisements are available at $15 a column inch. Size of type may be specified by advertiser. Answers to advertisements should be addressed to the box number, Classified Section, Chemical Engineering Progress, 25 West 45th Street, New York 36, N. Y. Telephone COlumbus 5-7330. Advertisements for this section should be in the editorial offices the 15th of the month preceding publication.

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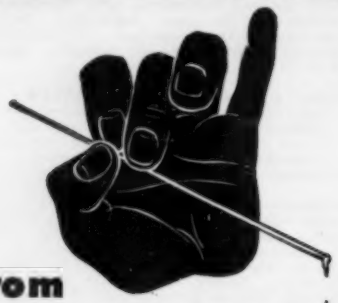

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IN MANAGEMENT AND TECHNOLOGY

(*Continued from page 97*)

Harold C. Weber is named chairman of the Chemical Corps Advisory Council by Army's chief chemical officer, Major General William M. Creasy.

Weber, a professor of chemical engineering at M.I.T., joined the advisory council in 1947. He succeeds the late Allan P. Colburn as chairman of the advisory group.

Having received a B.S. degree from M.I.T. and his doctorate abroad, Weber served in both World Wars in the chemical warfare service, as consultant in a Boston engineering firm, and from 1920, as professor at M.I.T.

Harry Litwin announces formation of Litwin Engineering Co. in Wichita, Kan., an organization engaging in design and construction of refineries, gasoline, and petrochemical plants.

Mr. Litwin, U. of Illinois graduate in chemical engineering and well known in the petrochemical industry, is president of the company.

In a recent announcement reporting company changes, **Lindley S. DeAtley** was named vice-president of research, development and production for the Thompson Hayward Chemical Co., Kansas City.

Louis D. Scott takes over as nylon liaison supervisor in the research and development department of The Chemstrand Corp.

With Chemstrand since 1952, Scott had served with Standard Oil, Ill.

N. A. Agapetus advances to position of chief process engineer at Port Neches, Tex., plant of Jefferson Chemical Co., Inc.

G. W. Burtt takes over as product specialist for ethanolamines and related products in New York.

Admiral Wilson D. Leggett, Jr., appointed vice president of engineering at American Locomotive Co., effective since his recent retirement from the Navy.

Richard F. Cassidy named production superintendent at recently established New Martinsville, W. Va. plant of the Mobay Chemical Co.

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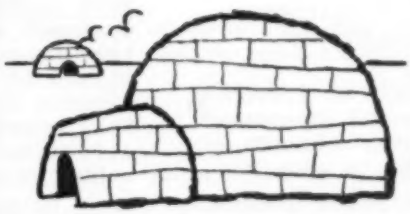

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news and notes

DOLLARS WAS THE MAIN TOPIC of conversation of the Council meeting in Louisville, Ky. . . . About four hours of the six-hour meeting was given over to Institute budgets, expenses, income, etc. . . .

THE FINANCIAL DISCUSSION CONTINUED after Council adjourned . . . earnest little knots of directors & members polling opinion on Council's decision to explore the feasibility of raising dues . . .

REQUESTED FOR THE AGENDA of the Houston Council meeting is the enabling legislation from the Constitution & By-Laws Committee raising the dues by one sixth . . .

THIS MEANS that if the Council discussion ends in a decision to go ahead, Members & Associate Members over thirty-five will pay dues of $21 . . . Associates under thirty-five will pay $14 dues . . . Student dues will remain at $1 . . .

IT SHOULD BE MADE CLEAR that the increase has not yet been made by Council, for such moves are not taken lightly . . . The directors want to tap member opinion about the increase and explain the reasons behind it . . .

MAIN REASON is increased cost of A.I.Ch.E. services owing both to general increased costs and also to the greater demands being made on the A.I.Ch.E. in general...

THE INSTITUTE BUDGET anticipates a loss for 1955 even without adding in the cost of the new A.I.Ch.E. Journal, which is not expected to be self-supporting for a number of years . . . WHAT IS CAUSE FOR CONSIDERABLE STUDY & CONJECTURE, however, is the cost of running the Institute itself . . .

THIS IS ONLY THE SECOND TIME in Institute history that a dues increase has been considered . . . Back in 1908 dues were pegged at $15 for Active Members and $10 for Junior Members . . .

IF ACCEPTED, THE NEW RATE will represent, over our whole forty-seven years, a $6 increase in dues for the Member group & a $4 increase for the younger members in the same period of time . . .

ACTUALLY COUNCIL MEMBERS FELT that the reaction of members to the increase would be favorable, since traditionally chemical engineers have an abundance of professional pride . . . also counted on is the fact that in the past ten years the A.I.Ch.E. has begun to develop a more aggressive program designed to bring more to chemical engineers and to the chemical engineering profession . . .

THIS COLUMN WILL KEEP MEMBERS INFORMED of all vital moves in this connection.

DURING THE MONTH OF MARCH Student Chapter counselors were appointed for Bucknell University . . . Octave Levenspiel to replace H. D. Sims . . . & University of Texas . . . David Cornell to replace B. J. Lerner.

J. G. KNUDSEN, who is Associate Professor of Chemical Engineering at Oregon State College, is also editor of the Student Chapter News, a valuable publication sent to subscribers in A.I.Ch.E. Student Chapters . . . Jim is now editing the paper with C. E. Wicks, also of Oregon State... Council approved funds to continue underwriting the publication for 1955.

UPON RECOMMENDATION OF DYSART E. HOLCOMB, Chairman of the Student Chapters Committee, Council approved a petition submitted by the University of Tulsa for a Student Chapter of the A.I.Ch.E. . . . This makes 102 chapters approved by A.I.Ch.E. for the chemical engineering students of the nation.

THIS IS THE TIME OF YEAR Student Chapter Conferences are popular & those which have come to our attention are listed here with the hope that all members of the A.I.Ch.E. who feel they can cooperate or aid in any way will do so . . . Northwest Regional Student Chapters Conference was held in the latter part of March at the University of British Columbia . . . Upper New York State Chapters, April 16 at Columbia University . . . North Central Student Chapters, April 22-23 at Wayne University . . . New England Student Chapters, April 23 at M.I.T. . . . Metropolitan Student Chapters, April 30 at Cooper Union . . . Texas Student Chapters, May 3 at the Shamrock Hotel, Houston . . . Southeastern Regional Chapters during April at Vanderbilt University . . . Arkansas Valley Student Chapters plan a conference some time in November at Oklahoma A & M . . .

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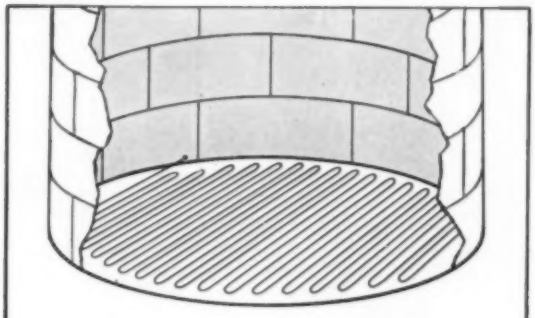
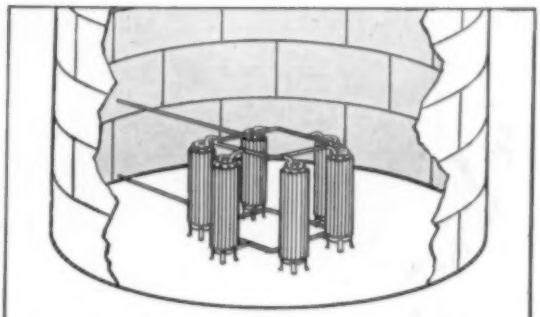


• Old-fashioned coils on the bottom of the tank are expensive to install. The pipes are soon covered over with sediment which seriously restricts the transfer of heat from the pipes to the tank liquid. The tank bottom is cluttered and difficult to clean.



• Our TF-18 Tank Heaters mount vertically. Sediment can not settle on the heat transfer surfaces. Heaters are entirely surrounded by tank liquid, assuring highly efficient heating of stored products year after year. Tank bottom is uncluttered, easy to clean.

Vertical Mounting

of BROWN FINTUBE TF-18 TANK HEATERS

assures more efficient, less costly heating of stored products

Our TF-18 vertically mounted tank heaters have obsoleted old-fashioned tank coils — and give users four outstanding advantages:—

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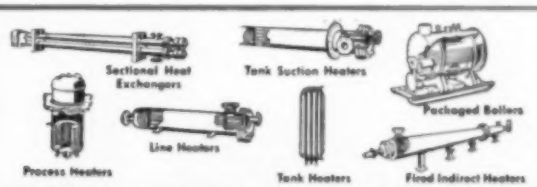

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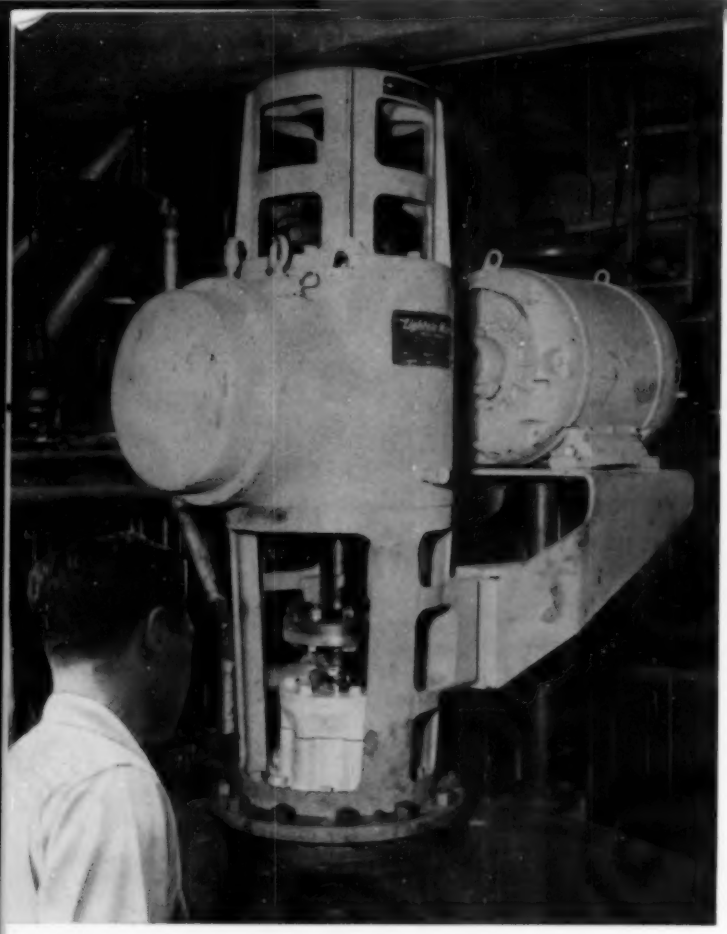
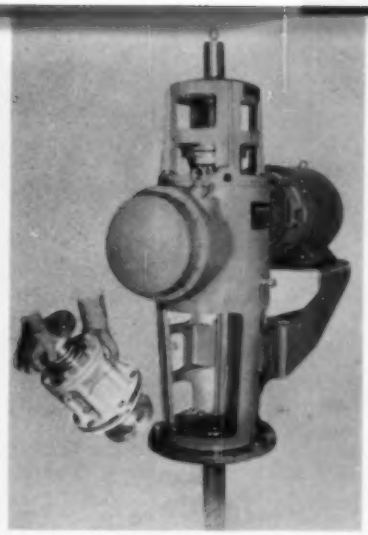
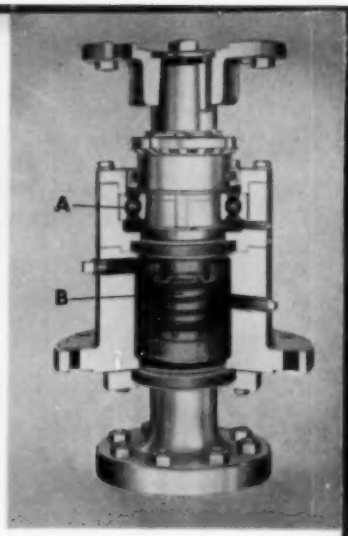




IF YOU CAN USE A WRENCH, you can replace a LIGHTNIN rotary seal in a few minutes. The mixer stays on the tank. Just unbolt and lift out this one-piece cartridge assembly; bolt a new one in its place; you're back in operation.



SMOOTH RUNNING. Prelubricated mixer shaft bearing (A) is part of seal assembly, close to seal for proper shaft support. But seal lubricant chamber (B) is separate from bearing—so you can choose best seal lubricant for your needs, without regard to bearing lubricant. Seal is stocked in wide range of designs and corrosion-resistant materials.

NEW LOOK in fluid mixing. This seal cartridge takes the place of a stuffing box; runs for years without adjustment; handles pressures to 1200 psig, temperatures from −120°F. to +485°F. Seals are optional equipment on LIGHTNIN top entering, side entering, and bottom entering mixers.

Newest cost-saver for fluid mixing:

End stuffing box repacking . . . forever

with a rotary seal that's easy to replace

You may get a whole new concept of the ease of mixing fluids under pressure or vacuum, when you read this story.

For here is a rotary seal that gives you leakproof, low-maintenance fluid mixing for *years*, under most conditions.

Yet *anyone can replace this seal in a few minutes*, if necessary. Without dismantling or demounting the mixer. Without draining the tank. And *without special skill.*

Here's what you gain when you specify LIGHTNIN Mixers with new LIGHTNIN Seals:

1. *You end leakage*—for good. The seal positively will not leak during its operating life. You can get standard LIGHTNIN Seal assemblies to handle pressures as high as 1200 psig; temperatures from −120°F. to +485°F. Special designs are available for more extreme conditions.

2. *You eliminate the cost* of repacking stuffing boxes. The LIGHTNIN Seal takes the place of a stuffing box. Under most conditions, it runs for *years* without changing.

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